POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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A Study in Still Life

ARTISTS WITH PREDILECTIONS toward studies in still life would find the new Hiram Walker Distillery at Peoria a veritable paradise. For there is probably more "still" life per square foot of ground area to be found there than anywhere else on the earth's surface. There are stills in every direction as far as the eye can reach. The landscape fairly bristles with them—large stills, small stills, tall stills, short stills, thin stills, fat stills, stills enough in fact to satisfy all the still life artists in the world for a generation to come. Indeed, it is no exaggeration to state that all the conglomeration of carrots, apples, turnips, dead fish and bunches of celery that have been portrayed in all the still life pictures ever painted could be placed in a single large still at Peoria and that the resulting brew would be potent enough to put all the still life artists in the world under the table for a month.

In the last issue it will be recalled we described the power plant at the Hiram Walker Distillery. More interesting perhaps than the making of power is the method of using it in an industry of this character, that is in the making of whisky and alcohol. So in this issue we present an article which discusses this aspect of this distillery. We can assure you that you will find this quite interesting for there are more angles to the making of whisky than you can see in the mellow glow of a bottle of bourbon. Al Capone, notorious in the art of distillation, is doing research work on some of these angles now in the quiet fastness of Alcatraz Island. But there are many others. In this picture, for example, you see a CO_2 scrubber hiding from the revenue officers between a group of fermenters. That's how careful they have to be in a place of this kind—they even scrub the CO_2 before making it into cakes. Where do they get the CO_2? Well, probably they could get it out of the power plant stacks but that is too much trouble so they have employed a special staff of bacteria to make it. This seems to have worked out nicely except for one thing, the bacteria insist upon working 24 hours a day and that of course is in violation of the NRA code. That's their worry, however, and we refuse to become disturbed about it. As we pointed out in the previous issue, this is the largest distillery of its kind in the world and experts have calculated that if the 100,000 gal. of whisky it produces in a day were turned into headaches, they would, if laid end to end, reach from here to next Fourth of July.

Perhaps you are not interested in distilleries. Well, then maybe we can interest you in something more highbrow—the article on the Distribution of Energy Charges by Linn Helander on page 450 for example. Mr. Helander, you recall, presented articles on the selection of equipment for economy in the June and July issues and is well versed in the art of squeezing the last available B.t.u. out of a pound of steam. Indeed, Mr. Helander begins to save heat units where others leave off. Most of us have been satisfied to strike a heat balance and then after making a few discreet modifications to make it look well send the result to the boss. It is just at this point that Mr. Helander steps in and shows us that heat balance is not everything it is cracked up to be and that all B.t.u.'s are not alike even though they were born in a single lump of coal. Maybe this explanation is not exactly correct but it gives you the idea. Don't take our word for it—turn to page 450 and read the article for yourself. The author has had a broad experience in the field of steam power engineering and in addition to being a consultant and research engineer was instructor in thermodynamics and power generation at the University of Pittsburgh.

Recently we came across an article in the General Electric Review on the subject of Instantaneous Voltage Regulation which discussed an aspect of direct current generator operation about which little has been written. It has to do with the elimination of "flicker" on direct current lighting systems due to switching. The article, however, was of a mathematical nature and we felt that because of the formidable looking equations it contained it might scare off many readers who otherwise would be benefitted by a consideration of this subject. So we obtained special permission from the author to abstract it and set about to reduce it to as simple language as possible. We eliminated nearly all of the mathematics, yet endeavored to retain as much as possible the author's presentation of the subject. The result appears on page 468 of this issue. It may give you some ideas, indeed if it does no more than merely acquaint you with this aspect of direct current operation it will have served its purpose. And if you are more deeply interested in the subject and wish to analyze it mathematically, the original article is easily available.

WITH THE EDITORS

Paper Progress

SINCE THE DAYS of paper profits, 300,000-kw. turbines and 1,500,000 lb. per hr. stokers, there has been no tangible evidence of unified progress in the power plant field. Certain industrial items have been improved, 1000 deg. F. steam has been successfully tried, 10,000 B.t.u. per kw. has been reached, buildings have been eliminated, automatic operation and supervisory control have been carried almost to perfection, critical pressure boilers have been built and operated, revolutionary new cycles have been hinted at.

Yet what the plant of tomorrow will be remains uncertain. What the first complete new plants built after the depression will be like remains a mystery even to designers. If load increases of the past 16 mo. continue the mystery will soon be solved, however, because new capacity will be needed in certain areas.

These stations will probably be at low cost, unbelievably low as measured by old standards, some say $65 to $75 is not too low an estimate. Plants will be simpler, perhaps around 800 to 875 lb. and 900 to 950 deg. F. without reheat and a heat rate of around 12,500 B.t.u. per kw. Buzzard Point, Schenectady, and Port Washington are somewhat intermediate designs representing advanced practice in the past along these widely divergent paths. The performance of these three stations will undoubtedly have considerable influence on the plants of tomorrow yet to be built.

In the meantime industrial plants have not been slow to take advantage of past central station practice and experience. Slag tap furnaces, binary vapor, 1400 lb. pressure and 100,000-kw. turbine units are already in use in this field. Whether they will become firmly established depends largely upon what the future brings forth in condensing power generation.

Reducing Peak Loads

WHETHER POWER is generated or purchased, peak loads are expensive and should be eliminated if possible. With purchased power memories of these peak loads are kept alive, often months after they happen, by the demand charge on the power bill. With power generated in the plant the additional cost in overhead due to a larger plant and standby equipment or to the additional risk involved in operating without adequate standby is not so apparent from month to month, although the lowered efficiency due to the peak loads is not so easily overlooked.

Many times the peaks can be reduced by careful scheduling of various process loads which occur intermittently. In one large plant the peak was cut about 400 kw. by this means. After an analysis indicated that a considerable portion of the early morning peak was caused by crushers and pumps which although intermittently operated were quite naturally started by the new operators each time a shift changed. A little study of the operating periods made it possible to prepare an operating schedule so arranged that the crushers and pumps never operated at the same time and neither operated during the normal plant peak period.

This is perhaps an exceptional case, but there is still another method that is equally effective, especially with purchased power. In every plant there are loads, such as compressors or pumps, that may be stopped for a few minutes without interfering in any way with plant operation. If these machines are stopped for a few minutes near the end of the peak period, the peak load for billing purposes can be held down to any reasonable amount set by the essential drives.

Demand limitators to do this automatically are available. They may be arranged to sound a signal at say the end of 12 min. of a peak period so that some of the non-essential machines may be shut down before the end of the period or they may be arranged actually to shut down the machines independently of the operator. Such peak control is one of the phases of industrial plant operation which warrants much thought and study.

Comfortable Atmospheric Conditions

AS TIME GOES on, cities and buildings become more densely populated and the necessity for air that is of correct temperature and humidity, free of dust and obnoxious gases becomes urgent, particularly in winter time when economy of heat demands closing windows and doors. The season of nose, throat and lung infections starts with the first frosts of the fall. Other causes of course exist in plenty but atmospheric conditions are major in their importance and the means of correcting them are finally available if not to every home at least to public buildings, institutions, office buildings and the most modern types of homes.

By all rights, conditioned air supplied to large buildings, institutions or factories is a power plant service since the equipment used requires engineering knowledge to operate it and keep it in working condition. Even residential units require motors for fans and pumps and thus depend upon the services rendered by utility plants.

Like many other developments, air conditioning has been a long time in receiving the public recognition which it deserves but today it seems on the verge of popularity similar to that of the electric refrigerator and, to foster this growing service, it is extremely important that air conditioning equipment be operated and controlled so that occupants of conditioned rooms are aware of greater comfort due to this service.

To establish satisfactory conditions is a problem facing the engineer in charge and the cut-and-try method, using the comfort chart published in the September issue as a starting point, seems to be the most logical procedure.

Hopper Paper Co. *Modernizes*

RECENTLY THE HOPPER PAPER CO. of Taylorville, Ill., manufacturers of high grade offset, fine writing and book paper, completed a modernization of its power plant as the result of a survey indicating savings of $31,000 a year. The mill, built about 1910, was originally steam driven throughout, the paper machine being driven by 13 by 16 in. Erie Ball engine, the auxiliaries by a 100 hp. Hamilton Corliss and the beaters and Jordans by a 500-hp. cross compound Corliss. The first two operating against a back pressure of 16 lb. supplied all the steam needed for drying and process. Steam at 125 lb. was supplied by seven h.r.t. boilers which were originally hand fired but to which stokers had been added about 1928.

Old Equipment Replaced

Motorization of the mill began about 1928. The Jordans were changed first, followed by the breakers and beaters, transit pumps and agitators until at the time the new plant was contemplated there were some 200 motors of all sizes in the plant and the electric load was somewhat over 280,000 kw. per month. At the average price of 1.15 cts. per kw. hr. this amounted to about $3225. Coal consumption at the same time amounted to about 724 t., worth about $1400, making a total power and steam cost of about $4600 monthly.

A survey indicated that a new power plant would save $31,000 annually, giving the new engines credit only for the steam used during the winter months. From the first few months' operation, indications are that the estimated saving will be exceeded and that the plant will pay for itself in approximately four years. Motorization is being continued and the contemplated replacement of the 100 hp. Corliss driving the paper machine auxiliaries will decrease this period considerably.

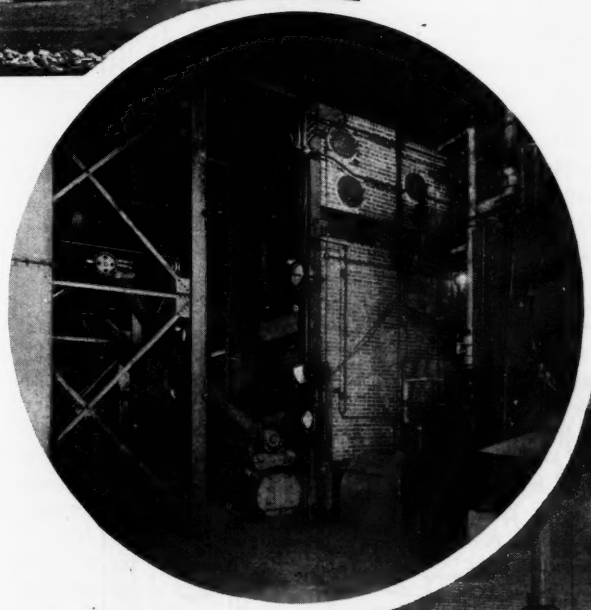
In the new plant two 4005 sq. ft., 200 lb., 100 deg. F. superheat Babcock & Wilcox Type H Stirling boilers replaced four old boilers and three Skinner Universal Unaflow engine generator sets, two rated at 400 kw. and one at 100 kw., replaced the 500-hp. engine. Three of the old boilers were retained for standby service. The paper machine and auxiliaries are still steam driven by the engines mentioned earlier, these engines being supplied with 125 lb. steam from the new boilers through a Fisher reducing valve and Schutte & Koerting desuperheater. The new engines operate at 175 lb. ga., 100 deg. F. superheat.

A photograph of the boiler room is shown by Fig. 2. The stokers operate under forced draft using one 4½ CLD Buffalo Forge Co. blower driven by a Troy 6 by 5-in. steam engine, regulated by the boiler pressure. The boilers have Babcock & Wilcox chain grate stokers, Diamond soot blowers, Copes feed water regulators, Reliance gage columns, Ashcroft steam gages, Bailey multi-point draft gages, Bailey steam flow-air flow meters and Republic CO_2 meters. Steam to the engines and steam to process is metered by Republic flow meters. Armstrong traps, Midwest piping and a St. Louis Steel Co. breeching were installed.

At present a Springfield ¾ by 3/16 in. cleaned coal is being used. This is handled by a Link Belt coal handling system consisting of a bucket elevator which carries the coal from the track hopper to the top of the boiler room, a screw conveyor which dis-

Power Facilities at Taylorville

Due to increasing electric load the Hopper Paper Company at Taylorville, Illinois, decided to rebuild the power plant and to generate its electric power at an estimated annual saving of $30,000



tributes it to the two 120 t. bunkers, and downspouts feeding the stoker hoppers.

One of the interesting features of the plant is the device, developed in the plant, located in the downspout and stoker hopper for tempering the coal and preventing segregation of the fires. This consists of baffles, a motor driven agitator shaft and a 1¼ in. steam line with ⅛ in. holes on 2 in. centers.

About 20 per cent of the boiler feed is return condensate, the balance is well water treated by a hot process softener. The raw water which runs about 14 gr. per gal. total hardness is pumped from three deep wells by Cook 300 g.p.m. turbine pumps driven by 20-hp. General Electric motors. These pumps, which are float controlled, pump to a 25,000 gal. elevated service tank from which the make up water is taken.

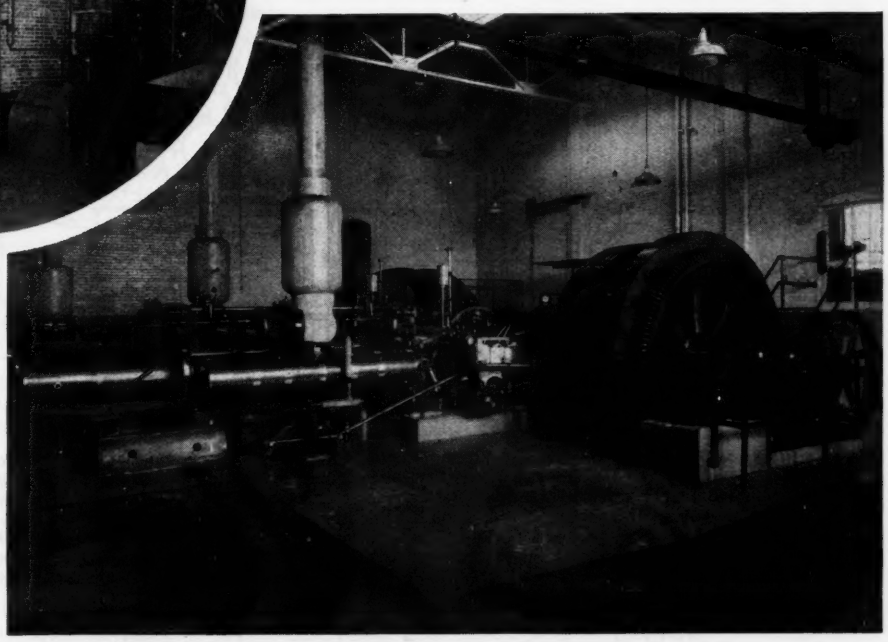


Fig. 1. Photograph of the mill taken while the smoke stack was being extended 50 ft. to handle the new boilers

Fig. 2. The two new boilers. Three of the old H.R.T. boilers were retained for standby, one of these is shown at the right

Fig. 3. Three engine generator sets were installed to carry the electric load which runs about 280,000 kw. per mo.

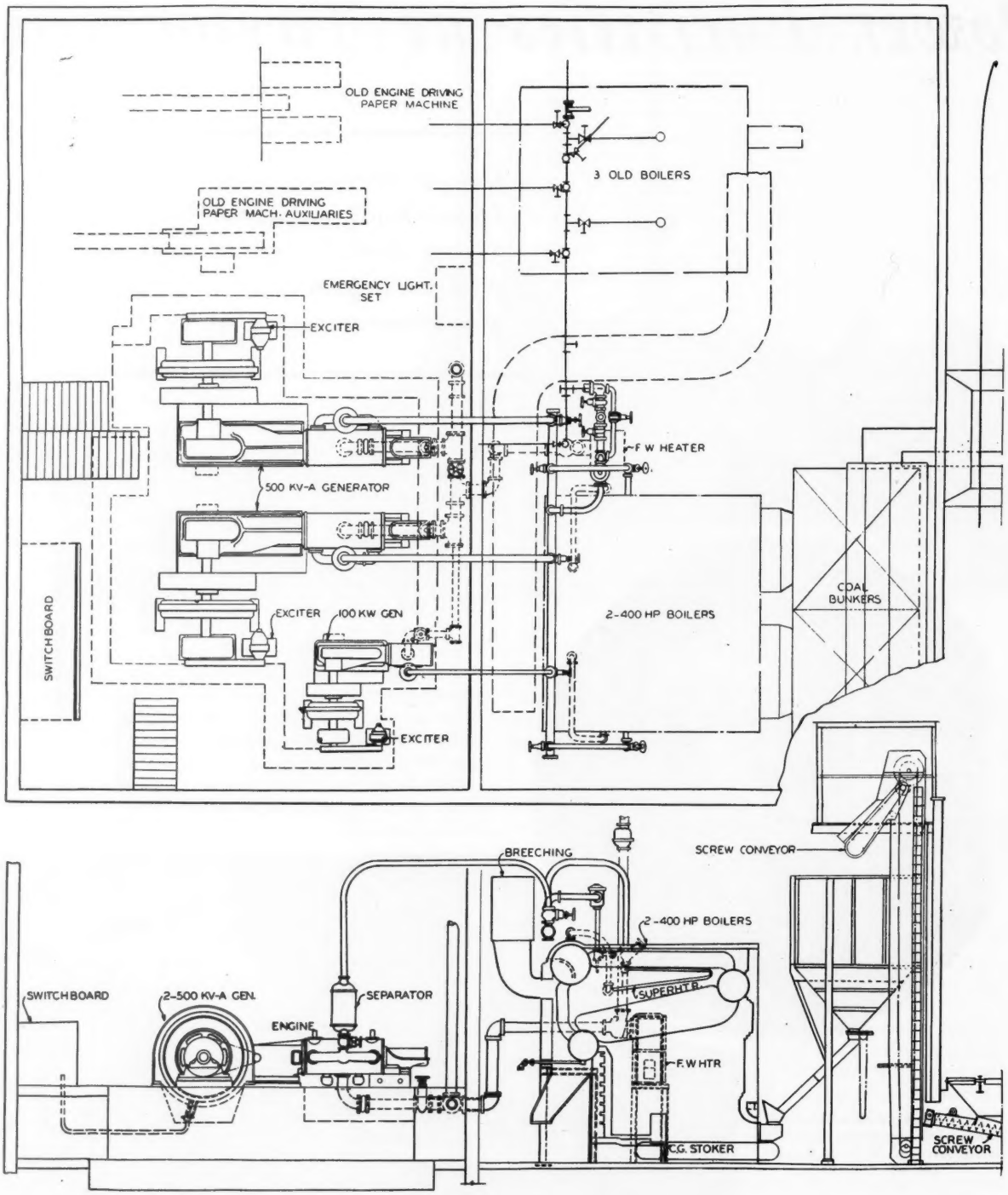


Fig. 4. Cross section and plan of the power plant. Four of the old h.r.t. boilers were removed to make room for two new 400 hp. low head room bent tube stoker fired boilers. The coal handling system consists of a screw conveyor which takes the coal from a track hopper and discharges it to a bucket elevator. The bucket elevator discharges the coal to a second screw conveyor which distributes it to the bunkers. In the engine room one old engine was removed and three new engine generator sets totaling over 1100 kv.a. installed. Two old direct drive engines and an emergency lighting set were retained. The engines drive the paper machine and paper machine auxiliaries which are to be changed to motor drive soon

Softened water is pumped by a 125 g.p.m. Fairbanks-Morse centrifugal pump to an elevated treated make-up tank. From this tank the water flows by gravity to the Swartwout feedwater heater as needed. The boiler feed pumps are 10 by 6 by 10 in. American-Marsh horizontal duplex outside end packed.

The three new engines are shown by Fig. 3. The switchboard is hidden by the right hand generator with only the top of the synchronizing panel visible over the top of the engine at the left of the flywheel. The arrangement of the three new engines and the two old engines mentioned previously is shown by the plan, Fig. 4. The small Engberg unit indicated is a 6¼ kw. set installed several years ago to take care of emergency lights and essential auxiliaries during power interruptions. It is retained in the new plant on the emergency lighting circuit but is no longer kept hot at all times.

Power Factor High

Both of the new large engines, 25 by 32 in., drive General Electric 500 kv-a. 3-ph., 60 cycle generators and V-belted exciters, while the third new engine, 15 by 16 in., drives a 125 kv-a. General Electric generator of the same voltage characteristics and exciter arrangement. All three engines operate at 5 lb. exhaust pressure maintained by a Fisher back pressure valve. Due to several large synchronous motors the power factor of the mill is usually close to unity giving a peak capacity of about 1125 kw. Normally the two large engines are operated, the small one being installed for light load and week-end service or to assist in carrying the load when it is too heavy for one and too light for both of the large units.

All three units are installed on a single foundation isolated from the building by 1 in. of Armstrong cork board and with the floor joints filled with Hydro-Proof cement. This foundation is 10 ft. 6 in. thick and has 435 cu. yds. of concrete.

The General Electric switchboard in the power plant consists of three generator panels, two feeder panels and one control panel with the necessary instruments, synchronizing equipment and voltage regulator. The main distribution board is in the mill in a location well protected from fire and water. All switches and breakers are totally enclosed and are mounted on steel panels.

All power is generated at 2300 v. and used at this voltage on the larger Westinghouse 250 and 300 hp. synchronous motors. Most of the smaller motors operate at 220-v., three substations being provided throughout the plant for this purpose. They have one bank of three 150 kv-a., one bank of three 75 kv-a. and one bank of three 15 kv-a. Moloney transformers for 200 v., 3 ph. service. In addition there is one bank of three 5 kv-a. units for 3 ph., 110 v. service and one 20 kv-a. single phase 220 v. unit.

The mill is located on the Wabash Railroad at Taylorville, Ill., about 30 mi. southeast of Springfield and has a capacity of about 200 t. of paper per week. The power plant was installed by the Skinner Engine Co. on pay out of savings contract. The coal handling equipment and stack were installed by the paper company on separate contracts. E. D. Frampton is general manager; C. E. Shaw is maintenance engineer and J. Ranney is chief engineer of the power plant.

Plant Modernization to be Featured at New York Power Show

ADVANTAGES of modernizing plant equipment to reduce power service costs and help restore industrial profits will be emphasized at the Eleventh National Exposition of Power and Mechanical Engineering, which now occurs every 2 yr., and will be held in the Grand Central Palace Dec. 3 to 8. Exhibitors, ranging from the largest, long-established corporations to new industrial organizations of modest size will display the latest developments in engineering, dynamic exhibits designed to tell their story clearly and prove how power service costs may be cut.

Three major expenses are involved in manufacturing; materials, labor and power supply, or material, men and machines. The last-named covers all items of generating, transmitting and utilizing power, including fuels, supplies, operation and upkeep and is the one where costs can be lowered, as the effect of Federal control unquestionably will be to increase the cost of materials and labor.

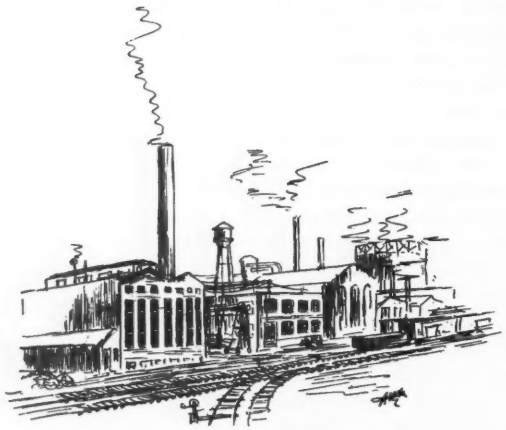
Reduction in power costs has long been urged, one estimate being that, in factory operation, saving of three-quarters of a billion dollars can be made by installation and efficient operation of modern equipment. This is stated to be more than the entire amount paid in dividends by manufacturing industries during 1933.

At the coming Exposition opportunity will be offered to those contemplating the purchase of equipment to clear up their difficulties in determining potential savings as compared with cost of modernization. From inquiries received, it is evident that the greatest interest is centering on complete power plants for industries, including boilers, air-conditioning, refrigeration and electric current supply. Diesel engines, especially, are arousing live interest.

This awakened interest in bringing power facilities up to date is a promising sign that better business is expected and that production expects to go forward. As the next exposition will be 2 yr. away, in 1936, manufacturers and buyers are alive to the importance of proving at this time the benefits of power-cost cutting by modernization.

To increase the life of wood poles or posts the Toronto Hydro-Electric System is using concrete sleeves, cast around the pole, leaving a space of 6 in. between pole and sleeve. The sleeve extends from a little above ground level to 18 in. below, the annular space being filled with pea gravel, sand and creosote, covered with a 1-in. seal of bituminous pitch. The creosote acts to impregnate the pole continuously, thus preventing or delaying destruction fungus growths at their most active point. Refilling is accomplished by breaking the pitch seal at two points, forcing in fresh creosote and resealing the holes. Cost is $6 per pole in paved locations, $4 in unpaved, and 60c for refilling. Increased pole life is from 10 to 15 yr.

Distribution *of* Energy Charges *in Industrial Plants*



By Linn Helander

Part 1. The use of the Heat Balance in considerations of power plant efficiency is well known. Heat balance, however is not the sole answer to the problem and, as shown in this article by Mr. Helander, often leads to inaccuracies. In a series of two articles of which this is the first, Mr. Helander analyzes the question of apportioning energy charges and shows how to distribute them equitably

UNRESTRICTED use of the heat balance as a basis for distributing energy charges in industrial plants using process steam leads to frequent unequitable distributions of these charges and to unreliable estimates of the costs of products manufactured. This is no basis for a broad condemnation of the heat balance method of distributing energy charges. That method has its use. It does not, however, take into account the grade of energy transmitted by steam, water, etc., to the various departments of a plant, but simply distributes charges for such energy in proportion to the quantity used by each department. It is inapplicable, therefore, when the grade of energy distributed by process steam is a consideration.

That is the case, for example, when steam is bled for processes from the turbines of a power plant that generates some part of its output on condensing units. It is also the case, so far as a distribution of heat charges among the industrial processes themselves is to be made, wherever low pressure steam obtained from some process can be employed advantageously on a large scale to replace higher pressure steam used by other processes; regardless of whether the power plant operates condensing or non-condensing.

Where the heat balance is inapplicable, the convertible energy balance, the manner of making which is illustrated by sample calculations given herein, should be used. That form of balance distributes energy charges and credit in terms of the mechanical or electrical energy that could have been produced by the energy for which a charge or credit is assigned if it had been used in a condensing steam power plant of defined efficiency employing local circulating water of the lowest available temperature.* It, therefore, makes a higher charge, unit for unit, for heat delivered by high pressure steam than it does for heat delivered by low pressure steam. It provides the only satisfactory basis for distributing process heat charges where the replacement of high pressure steam used in processes by low pressure steam is conducive to overall economies, and, in addition, it discloses sources of inefficiencies with clarity. No better tool, when properly used, is available to management for reducing fuel costs.

*When the defined efficiency is that of an ideal plant, the convertible energy balance is referred to as an available energy balance.

Use of Heat Balance Method

At the present time, the heat balance method of distributing energy charges is virtually the only one used by industrial plants. One reason for this is the fact that the convertible energy balance method is not so familiar as the heat balance method to the average operating engineer, but a more important reason is the widespread opinion among industrial engineers that the heat balance method gives a more equitable distribution of charges than does the convertible energy balance method. This opinion, although justified for some conditions of operation, is for other conditions unsound.

Specifically, use of the heat balance method is justified for the entire plant where all of the steam supplied to the power generating units is used subsequently by industrial processes in the form of bled and exhaust steam, and where, in addition, an increment of heat supplied to any industrial process adds an approximately equal increment to the total demand of the plant for process heat. Its use for the entire plant is not justified where these conditions do not prevail.

Where all of the steam supplied to the power generating units is used subsequently by industrial proc-

esses (see case Ia for an example of this), the overall heat consumption of the plant, exclusive of boiler losses, is equal to the amount of heat consumed by the industrial processes plus that lost by radiation, etc., plus that converted into work not returned to the feedwater by the feed pump. Thus for this case, the following formula applies:

Total amount of heat consumed per hour by plant, exclusive of boiler losses =

$$\frac{3415 \times \text{kw}}{e} + \text{heat consumed per hr. by processes} + \text{heat lost per hr. by radiation, leakage, etc., — energy returned per hr. to feedwater by feed pump† + heat consumed per hr. by steam driven auxiliaries.}$$

In this formula, kw. is the load on the power generating units and e is the combined mechanical and generator efficiency of these units. So long as the conditions of operation are such that the above formula is valid, an increment of heat conversion or of total process heat demand will produce an approximately equal increment of plant heat consumption, regardless of the level of convertibility of the increment of energy supplied to the power generating units or utilized by the processes.

Thus the addition of 1000 B.t.u. per hour to the demands for heat for industrial processes will add, under the conditions for which the formula is valid, approximately 1000 B.t.u. per hour to the total plant heat load regardless of whether the heat is supplied to these processes by steam at a pressure of 500 lb. per sq. in. or by steam at a pressure of 10 lb. per sq. in. when, in addition, the conditions are such that an increment of heat supplied to any particular process adds an approximately equal increment to the total demand of the plant for process heat, then one is justified in charging each department of the plant for the heat consumed by it rather than for the convertible energy consumed.

Furthermore, it will prove advantageous to do so; for, as will be seen later, charges apportioned in accordance with the amount of heat consumed by the various departments of the plant lead to low charges for power and relatively high charges for process heat. They therefore encourage operators to make additions to the power load, desirable at least up to the point that a condenser must be installed in the power plant, and reductions in the demand for process heat; the former through the sale of power to utilities and the electrification of processes, the latter through the use of multiple effect evaporators, in place of single effect evaporators, the recovery of heat from waste water, etc.

Both additions to the power load and reductions in the demand for heat by individual industrial processes will be found economical, when justified on the basis of energy charges made in accordance with the heat balance, so long as all of the steam supplied to the power generating units is used subsequently in industrial processes and in addition an increment in the demand for heat by any process adds an approximately equal increment to the plant demand for process heat. Under these conditions, therefore, use of the heat balance method of distributing energy charges is both equitable and conducive to economy.

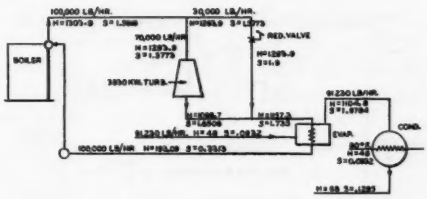
†Energy returned by feed pump to feedwater usually neglected except at high pressures.

Cost Distribution in Multiple Effect Processes

Where the conditions of operation are such that all of the steam supplied to the power generating units is used subsequently in industrial processes, designated here as Case Ib, and, in addition, the industrial processes are themselves arranged so that low pressure steam may be bled from certain ones of these for use in others, as when steam may be bled from the intermediate effects of multiple effect evaporators for use in adjoining processes; the formula previously given will apply, but under these conditions increments of heat

Case Ia. Non-Condensing Power Generation Exclusively

No steam bled from one industrial process for another. For this case the heat balance method of distributing energy charges is satisfactory; since here a decrement or increment of heat consumption in any department produces an approximately equal decrement or increment of plant heat consumption, regardless of the grade of heat conserved or consumed.



Heat and Available Energy Balances

Item	Heat Consumed B.t.u./Hr.	Heat Consumed Per cent of Total	Avail. Energy Consumed B.t.u./Hr.	Avail. Energy Consumed Kw.	Avail. Energy Consumed Per cent of Total	Charge
1. Radiation in header	1,000,000	0.9	757,000	221	1.74	General
2. Turbine	15,444,000	13.9	14,439,000	4210	97.70	Power
3. Reducing valve	2870	2870	5,825,000	1705	13.60	Evap.
4. Header to evaporator	2870	2870	517,000	151	1.19	Evap.
5. Evaporator	2870	2870	17,060,000	5000	39.25	Evap.
6. Condenser	94,593,000	85.2	2,900,000	1025	6.68	Evap.
7. Condensate from condenser	1,628,000	1.5	24,000	11	.06	Evap.
8. Total	111,081,000	100.0	43,506,000	12,703	100.00	

Recapitulation of Heat Charges

Item	Distribution of Heat Charges		Unit Charges Against Power		Unit Charges for Process Heat	
	Based on Heat Balance Per cent of Total	Based on Avail. Energy Balance, Per-cent of Total	Based on Heat Balance B.t.u. per Kw-hr.	Based on Avail. Energy Balance B.t.u. per Kw-hr.	Based on Heat Balance B.t.u./B.t.u.	Based on Avail. Energy Balance B.t.u./B.t.u.
1. Evaporator	87.4	61.7	-	-	1.01	.71
2. Power	12.4	38.3	3600	11,109	-	-

supplied to particular industrial processes will no longer add, in general, equal increments to the total plant demand for process heat.

For these conditions, it is the writer's opinion that the most satisfactory procedure is to assign to the power station those charges that fall to it when the heat balance method of distributing charges is applied to the entire plant, and to assign to the individual industrial processes those charges that fall to them when the convertible energy balance is used for the entire plant. The residue of unapportioned charges may then be treated as general or overhead charges to be distributed in the usual manner of distributing such charges. The result will be a relatively low charge per kilowatt-hour for power, which is in the interest of economy, and an equitable distribution of charges among the industrial processes.

Condenser Changes Energy Distribution

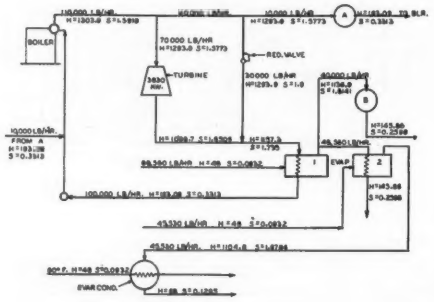
In contrast to the conditions that exist when all of the steam supplied to the power generating units is used subsequently by the industrial processes, are the conditions that exist when the power plant supplying process steam operates partly condensing. Then an addition to the heat load of the process end of the

plant in general no longer adds an equal or even a related amount to the total heat demands. Instead, the increment of total heat demand is, in this case, a function almost exclusively of the increment of convertible energy consumed, being approximately a constant multiple of this.

For these conditions, the convertible energy balance and not the heat balance should be used as the basis for distributing energy charges. If this is done, each department of the plant will be charged approximately for the amount it adds to the total heat demands of the plant, which is equitable, and not for the amount of heat supplied directly to it. Furthermore, this method of apportioning charges will be found conducive to economy, for it encourages the use of heat of low convertibility and therefore the use of low pressure bled or exhaust steam in preference to high pressure steam.

Case Ib. Non-Condensing Power Generation Exclusively

Steam bled from evaporator for other processes. For this case it is suggested that the power station bear those charges which fall to it when the heat balance method of distributing charges is used for the entire plant; the individual industrial processes, those charges that fall to them when the convertible energy balance method is used for the entire plant. The residue of unapportioned charges may then be absorbed as plant overhead or general charges.



Heat and Available Energy Balances

Item	Heat Consumed B.t.u./Hr.	Heat Consumed Per cent of Total	Avail. Energy Consumed B.t.u./Hr.	Avail. Energy Consumed Kv.	Avail. Energy Consumed Per cent of Total	Charge
1. Radiation in heater	1,100,000	0.9	655,000	844	1.74	General
2. Turbine	13,644,000	11.2	16,430,000	4210	34.35	Power
3. Reducing valve	Zero	Zero	5,225,000	1535	10.90	Evap.& Proc. B
4. Heater to evaporator	Zero	Zero	517,000	151	1.08	Evap.& Proc. B
5. Evap. offset No. 1	Zero	Zero	6,490,000	1900	13.55	Evap.
6. Evap. offset No. 2	Zero	Zero	5,581,000	1640	11.66	Evap.
7. Evap. condenser	47,804,000	39.4	1,740,000	512	3.64	Evap.
8. Condensate from evap.cond.	911,000	.7	10,000	3	.04	Evap.
9. " from evap. offset No.2	4,752,000	3.9	384,000	113	.80	Evap.
10. Process A	11,008,000	9.0	4,280,000	1258	8.94	Proc. A
11. Process B	39,640,000	32.5	6,049,000	1778	12.63	Proc. B
12. Condensate from Process B	3,910,000	3.1	316,000	93	.66	Proc. B
13. Total	122,169,000	100.0	47,913,000	14,031	100.00	

Recapitulation of Heat Charges

Item	Distribution of Heat Charges Processes charged with boiler heat equivalent of available energy consumed; Power with heat converted plus losses B.t.u./Hr.	Per Cent of Total	Unit Charges Against Power B.t.u./Kw-Hr.	Unit Charges for Process Heat B.t.u./B.t.u.
1. Evaporators	47,800,000	38.7	-	.895
2. Process A	11,150,000	9.1	-	1.010
3. Process B	21,200,000	17.2	-	.405
4. Power	13,900,000	11.3	3400	-
5. Undistributed*	28,839,000	23.6	-	-

*To be absorbed as an overhead or general charge against all processes

Case Ia is that of a plant in which a non-condensing turbine supplies low pressure steam to an evaporator which in addition derives some steam from the boiler directly through a reducing valve. In this case all power generated is by-product power. No steam is bled in this case from processes.

The heat balance distribution of energy in Case Ia gives a heat charge of 3600 B.t.u. per kw-hr., exclusive of boiler losses, for the energy consumed in generating power; the available energy balance distribution, a heat charge of 11,108 B.t.u. per kw-hr., exclusive of boiler losses. On the basis of the heat balance, the charge for heat used by processes is 87.6 per cent of the total heat supplied by the boiler; on the basis of the available energy balance it is 61.7 per cent. Thus the heat balance leads to a relatively low charge per kw-hr. for power consumed and to a relatively high charge for heat used by the industrial processes. These results are desirable ones in this case, for they encourage the operator to effect economies in the use of process heat and to make additions to the power load.

Both of these effects, if realized, will reduce the flow of steam through the reducing valve and thus improve the economy of the entire plant, provided, of course, the additions made to the power load are themselves economical and the economies in the use of process heat have not been made by installing excessively expensive equipment.

Unfortunately, the heat balance distribution of charges gives no clue to the inefficiency caused by the reducing valve. It represents the plant in this case

Effects of Seasonal Changes

In some industrial plants, conditions during the winter months are such that all of the steam supplied to the power generating units is used subsequently either by the industrial processes or for heating buildings, while during the summer months condensing operation must be resorted to. When this is the case, the heat balance may be used as a basis for distributing energy charges during the winter months and the convertible energy balance may be used during the summer months.

In other plants, existing conditions may justify the use of the heat balance as the basis for distributing current energy charges, but new conditions arising may soon make the use of the convertible energy balance advisable for this purpose. When this is the case, the operator should choose that basis for making current energy charges which best suits his needs, bearing in mind that the heat balance method leads usually to a low charge for power and a relatively high charge for process heat, while the convertible energy balance leads to a high charge for power and usually a relatively low charge for process heat.

One danger in the use of the heat balance method of distributing energy charges in this case lies in the encouragement it gives to an extension of the power load. Because of the low charge that it makes for power, one may be induced by it, for example, to introduce electrifications which will prove uneconomical as soon as this low charge for power is no longer warranted. Use of the convertible energy balance instead of the heat balance will prevent this, but the convertible energy balance has the disadvantage in this case that it leads to a charge for process heat lower than the current cost of such heat.

In order to illustrate the relative merits of the two methods of distributing energy, and to show in what respects the results to which they lead differ, energy charges have been distributed on the basis of the heat balance and that form of convertible energy balance called the available energy balance* for five different conditions of plant operation, indicated as cases Ia, Ib, II, III, and IV. Cases Ia and Ib are discussed in this installment, while cases II, III and IV will be considered in a later issue.

as one operating at approximately the maximum of efficiency, whereas the available-energy balance distribution of charges indicates that approximately 13.2 per cent of the heat consumed may be saved by raising the pressure of the exhaust steam and adding evaporator effects so as to eliminate the flow of boiler steam through the reducing valve, leaving the available energy consumption of the evaporators unchanged.

Case Ib

Case Ib is the same as Case Ia, except that steam is bled from one process for use in another.

The method adopted for distributing energy charges in Case Ib has been outlined. In accordance with the procedure therein outlined, the power station has been charged with the heat actually converted plus apportioned radiation losses; the processes with the boiler heat equivalent of the available energy consumed by them plus apportioned losses of available energy. The result is a heat charge of 3600 B.t.u. per kw-hr. against power, and heat charges against processes ranging from 0.49 B.t.u. per B.t.u. of heat consumed to 1.01 B.t.u. per B.t.u., according to the level of convertibility of the heat used by the individual processes. Process B, which uses only low pressure steam, bears a charge of 0.49 B.t.u. per B.t.u. of heat consumed; process A, which uses only boiler steam, a charge of 1.01 B.t.u. per B.t.u. With this method of distributing charges, there is an undistributed heat charge equal, in this case, to approximately 23.6 per cent of the total charge. This undistributed charge should be treated as a general or overhead charge to be absorbed by the products of the plant in accordance with their abilities to absorb overhead charges.

(To be continued.)

Turbine Drive *for* Underfeed Stokers

Small Turbine Governor Responsive to Both Speed Changes and Combustion Control Improves Stoker Drive. By H. S. Johnson*

TO DRIVE underfeed stokers by a turbine, when regulated by some type of combustion control, the problem of constant speed at any point set by the automatic regulator is not accomplished by the ordinary means of throttling the flow of steam, such as chronometer valves or similar devices, which allow the steam to flow to the turbine in amounts determined by the rise and fall of the pressure in the steam header.

While it is true that the changes in steam pressure should regulate the amount of coal fed into the furnace, it does so by providing valve openings determined by these pressure changes that allow a fixed flow respective to the change. This should give a constant speed for a particular position of the automatic regulator, provided the stoker load or torque does not change.

The fact that the torque does change, since no stoker has an even torque for the complete revolution of its crank shaft, is well known but overlooked by many purchasers when considering turbine drive for the stokers. The result is that on light boiler loads the stoker must be operated intermittently or stalling of the drive may occur. On heavier boiler loads the drive may not stall but the speed varies with the torque. Many installations are installed in this manner when there is no need of it. It can be prevented if there is a connection between the speed responsive governor on the turbine and the movement of the combustion control mechanism.

There is no better way to drive a stoker than with a turbine because it offers excellent speed control features. The matter of obtaining speed responsive governing in conjunction with automatic combustion regulation for the amount of coal fed as determined by the change in steam pressure is not difficult. Speed compensation when two governors are acting on the same turbine simultaneously is not new, but generally sufficiently elaborate to keep them off turbines of such small sizes used for this purpose.

One of the simplest and perhaps the most positive of turbine governors is the hydraulic governor of the oil impeller type, as it supplies both the means of governing and a strong motive force to operate the turbine governor valve. Also, by a simple attachment the master regulator of the automatic control may be connected to the turbine governor so that both types of governing may be had. The cycle of operaion is as follows:

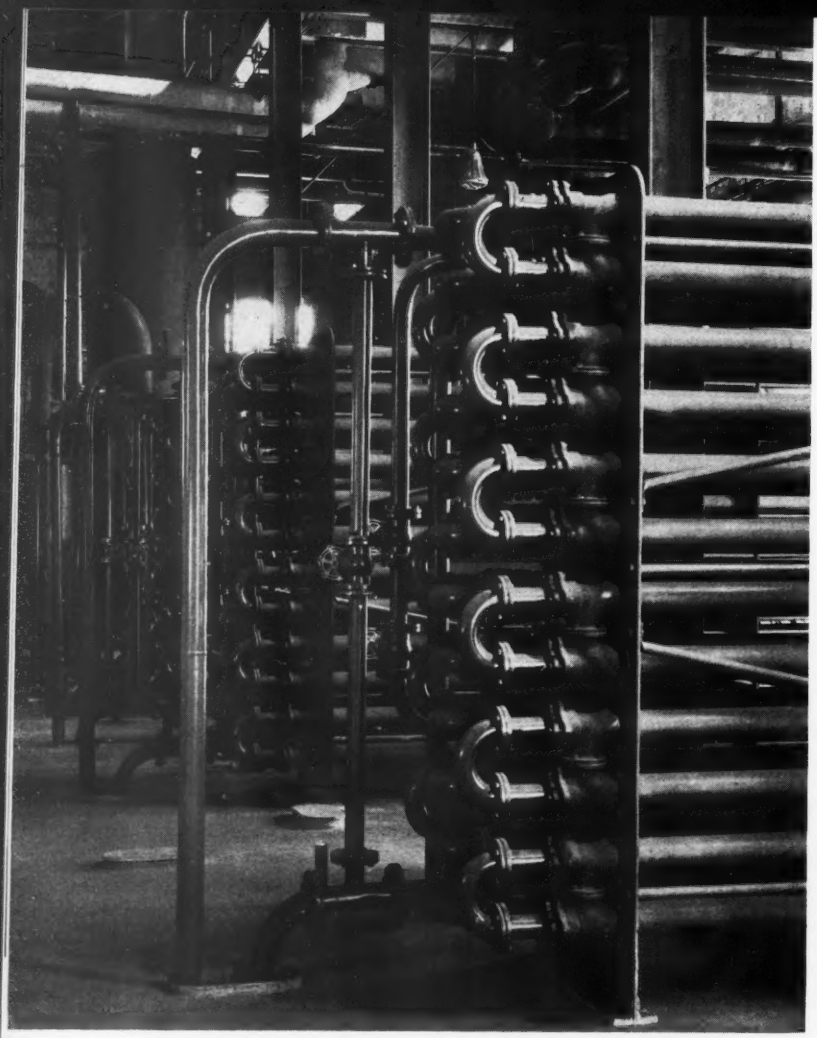
Oil Pressure Varies

The governor oil impeller pumps oil at approximately 70 lb. per sq. in. pressure at full speed. The discharge pressure varies as the square of the speed and this change in pressure is used for speed responsive governing with normal speed variation of about 2 per cent. The oil, under pressure, is fed directly to a piston or ram to which the turbine inlet valve is attached. The ram is opposed by a heavy coil spring so that the valve opening is regulated by the balance between the oil pressure and the force of the opposing spring. Therefore, by changing the effect of the opposing spring the speed of the turbine may be altered without changing the normal speed variation of the turbine governor. For example, if the spring is compressed the turbine speed increases, the oil pressure also increases until equilibrium is established and the governor comes to rest at a higher speed level. For a lower speed level the reverse takes place.

When combustion control is used the movement of the master regulator, through its relay, compresses and releases the tension on the governor valve spring and establishes the level of speed for the steam demands. Since the speed responsive governing is not disturbed, variations in torque from the stoker itself do not affect the speed except for the slight amounts required to alter the governor valve position.

An added feature with this type of governing is the coal feed indicator gage. Since the speed of the turbine is always proportional to the discharge pressure of the governor oil impeller, an oil pressure gage is supplied graduated in pounds of coal per hour, so that a direct reading may be had of the quantity of coal fed into the furnace. This is very helpful to the operator whether he is operating on automatic or hand control of the stoker speed.

*Westinghouse Elec. & Mfg. Co., Boston, Mass.



The World's —*Hiram*

Part II. Last month we presented in these pages a description of the new power plant of the Hiram Walker Distillery at Peoria. In this article we continue the discussion of this plant with a description of the process details at the distillery, showing how the steam and electric power generated in the power plant is utilized in the process of making whisky and alcohol

Fig. 1. Above the stills where the whiskey vapors are condensed

POWER AND STEAM facilities consist of two 180,000 lb. per hr. Stirling boilers and two 1500 kw. General Electric extraction-back pressure turbines. The following pages tell how this power and steam is used in making 100,000 gal. of whisky every 24 hr.

Grain as received is unloaded from cars by Fuller Airveyors, a vacuum system with the exhauster located on the top floor of the mill building. From the top floor the grain is weighed by Richardson automatic scales and passes through scalpers (vibrating screens) to a screw conveyor which distributes it to one of nine concrete bins. Two Airveyors, with exhausters driven by 100 hp. Allis-Chalmers motors through Texrope drives, are installed with suction lines arranged so that cars can be unloaded from the Peoria & Pekin or Rock Island tracks either separately or simultaneously. Each conveyor has its own scales, magnetic pulley, scalper and screw conveyor (driven at 135 r.p.m. by 10 hp. Allis-Chalmers motors through Falk gears) so that any grain can be delivered to any bin or two different grains can be handled simultaneously. The grains are corn, rye, barley, rye and barley malt.

From the bins the grain flows by gravity through push button-operated gates to 12 Allis-Chalmers, three high roller mills, located on the ground floor in batteries of four, the dump pocket of each battery being driven by a 2 hp. motor. Each mill is driven by a 20 hp. motor through a close belt drive. From the mills the meal is returned to the top floor by one of two Airveyors (exhausters driven by 75 hp. Allis-Chalmers motors) and distributed by screw conveyors to one of 10 bins. These bins are concrete with steel bottoms.

From the bins, meal is weighed and fed to the cookers, by six screw conveyors, each driven by a 7½ hp. Westinghouse gear motor, and for convenience, divided into two groups of three, each known as the wet and dry conveyors. Some meal, such as corn, can be fed dry to the cookers. This is fed through the top of the cooker by the dry system. Others such as rye meal have a tendency to ball up if fed dry so must first be moistened in Porteus mixers, high speed agitators with water jets, which mounted at the top of the cooker, take the meal from the so-called wet conveyors and discharge direct to the cookers. Water for the Porteus mixers is maintained at 120 deg. F.

Eight Vulcan cookers are installed. These are large cylindrical 13,852 gal. steel vessels with the necessary water, meal, steam and mash connections. Each cooker is well insulated and has an agitator driven at maximum speed of 24 r.p.m. by 25 hp. Wagner two speed motor through Universal gears. Steam for cooking at 75 lb. is supplied through the bottom by 24 one inch pipes from a 6 in. manifold. The cooker is filled about half full of 180 deg. F. water, the corn meal added and the steam turned on. It takes about 40 min. to get the cookers to the desired temperature of 312 deg. F. This is held a few minutes and the cooker cooled by flashing. The other ingredients, such as rye and malt, are then added and cooking continued at a lower temperature which depends upon the particular formula

Largest Distillery

Walker & Sons, Inc., Peoria, Ill.

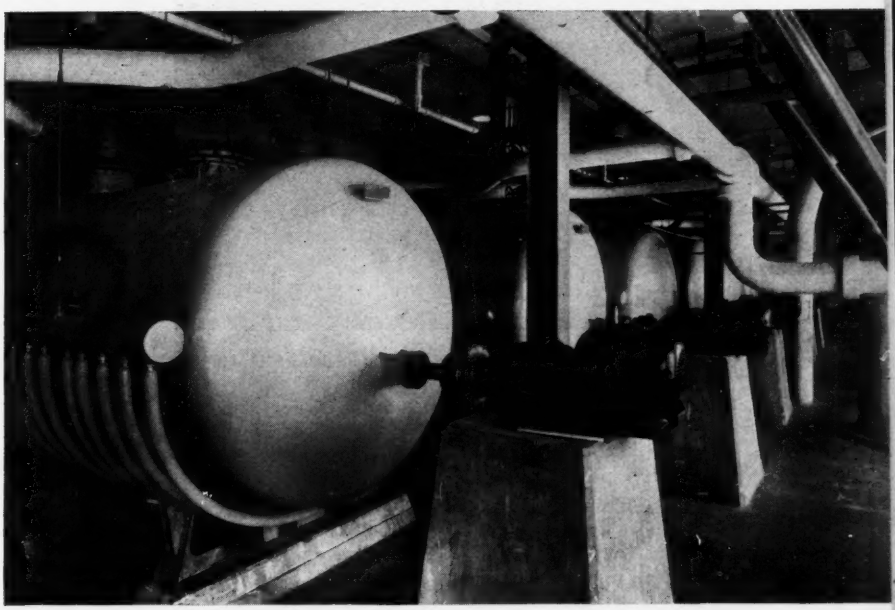


Fig. 2. Meals of various kinds are mixed and prepared for fermentation in these cookers

being used. The complete cycle takes 2 hr. 40 min. which means that a cooker is started every 20 min., giving a fairly constant steam demand.

During the cooking process the cooker contents are cooled by flashing in two stages. The first stage cools to about 215 deg. F. by flashing to the atmosphere through a heat exchanger which heats the incoming water to the other cookers. In the second stage the cookers are cooled to 165 deg. F. by flashing to a barometric condenser. One of these condensers is supplied for each pair of cookers.

With manual operation something over 130 separate operations are required for each cook. To simplify operation a push button control was devised by the designers working with the Richardson Company, which supplied all the scales, Robins Conveying, which supplied all the conveyors, and Westinghouse. Meal, malt, hot water and steam to the cookers, venting, cooling and dumping are all controlled by Cutler-Hammer motor operated valves from a central switchboard. Opening the meal valve on any cooker energizes an interlock system which controls in sequence, opening of the gates, starting the conveyor, weighing out a predetermined quantity of meal and delivering the meal to the cooker (either wet or dry as desired), closing the gates and stopping the conveyor.

From the cookers, the mash flows by gravity to drop tubs, one for each two cookers, which act as surge tanks for the pumps, handling the mash through double pipe coolers to the fermenters. These are two Vulcan double acting, two cylinder pumps with external weighted check valves and driven by Wagner 25 hp. motors, through Falk gears at 36.6 r.p.m. They are popularly known as grasshopper pumps because of their walking beam and odd crank construction which allows the length of the stroke to be adjusted at will. The four mash coolers are double stand, two tubes wide and 11 high by 60 ft. long. The outer pipe takes cold water which is circulated through the 22 tubes in series. The inner tubes, 3 in. in dia., take the mash which can be circulated through the 22 tubes in series or through two 11-tube sections in parallel. A slop cooler adjacent to the mash coolers is of the same construction, and is used for cooling slop used for back-set in the fermenters.

Mash, cooled to 90 deg. in the double pipe coolers is delivered to the Ansonia Graver fermenters, 117,442 ga. vertical copper-bearing steel tanks with curved top and bottom. They are fitted with copper cooling coils by which the temperature is maintained during the 72 hr. fermenting period at about 85 deg. F. by water under control of Tagliabue regulators. Twenty-four of these fermenters are installed, eight filled each day. In addition to the mash from the cookers, a certain percentage of slop, returned from the dryer house, and yeast are added. The slop, before being added, is cooled by a double pipe pass cooler of the same design as those for the mash. Additional make-up water needed is supplied at 85 deg. F., this temperature being secured by mixing hot water from the 180 deg. F. system with well water by a Tagliabue control.

Yeast is cultivated in a separate building which in addition to two copper pure yeast machines and lactic and culture tubs and twelve 9903 gal. Byers wrought iron yeast tubs has, on the top floor, two

Fig. 3. Roller mills where grains are ground before cooking

research laboratories which are separate and distinct from the plant control laboratory located on the third floor of the power plant. Wort and mash for yeast culture is cooked in a separate cooker adjacent to the drop tubs. The fermenting or culture period in the yeast tubs is about half that of the fermenters, so that one tub can take care of two fermenters. CO_2 from the fermenters is piped to the CO_2 building and sold to the Liquid Carbonic Corp. The solidifying plant of this company has a capacity of 25 t. per day but this will eventually be increased to 100 t.

From the fermenters, the product now known as beer or mash beer flows by gravity to one of two Graver 150,000 gal. steel tanks, or beer wells. From the wells, the beer is pumped by 450 g.p.m. Worthington centrifugal pumps to an overhead constant level tank from which the proportioning pump takes its suction. These proportioning pumps are of the same grasshopper type as the mash pump but are driven through a Reeves transmission so as to give variable speed. One side handles beer to the still, the other side handles slop, beer from which the alcohol has been distilled, from the still. The variable stroke design of the pump allows proportion of slop to beer handled to be varied at will.

There are two bourbon whisky stills, one Vulcan and one Ansonia, a Vulcan charge still with doublers and doubler kettles for rye whisky, two Badger continuous stills for high proof spirits, a gin still, and a Struthers Wells water still. The bourbon whisky still is shown in the flow diagram because of its simple construction, and continuous operation. From the constant level tank the proportioning pump forces the beer through a beer heater and heat exchanger into the top of the still or column. Fifteen pound steam enters at the bottom of the column and bubbles up through the beer which flows downward over a series of screens. Vapor distilled off passes first through the beer heater (the first stage heater for the incoming beer) and then to a closed condenser on the still column. The liquor condensed in the beer heater is returned to the still for rectification or redistilling. The waste beer from the bottom of the still, now called slop, is picked up by the proportioner pump and forced through the heat exchanger (the second stage heater for the incoming beer) to the dryer house to be made into stock feed.

This slop is dried in the dryer house built adjacent to the power plant. Slop as it is received is screened by five Davenport screens, the moisture pressed out and the solids dried in five Tyler-Harmon rotary steam dryers using 75 lb. steam and each having a capacity 112 t. per day. A portion of the light slop screened out is returned to the fermenter house for backset and the remainder is evaporated in a quintuple effect evaporator, using 15 lb. steam in the first stage, and the residue returned to the dryers. Dried grains are blown to a storage bin at the top of the building until sold for stock feed.

Rye whisky is made in the charge still constructed in three sections or chambers. This still is operated by dropping the contents of the boiled out bottom section into the slops, dropping the contents of the upper chambers to the one below and filling the top chamber with beer. Steam at 15 lb. enters the lowest chamber at the bottom, the vapor passing successively through the upper chambers and through the doublers to the condenser; the condensate passing to the low wine storage tank from which it is drawn to the doubler kettles and the beer redistilled. In these kettles, 75 lb. steam is used, and the high proof vapor is condensed, cooled and passed to storage. Operation takes place in a 27 min. cycle controlled by automatic devices and remote controlled valves. Gin is made by distilling alcohol over various mixtures of orange peel, juniper berries, etc., to give it a flavor. Distilled water is needed for cutting back the whisky to 104 proof for barreling, the finished whisky is about one-third distilled water.

High proof spirits or alcohol are made in the Badger continuous stills, made up of a beer column, aldehyde separating and concentrating column, fusel oil column and alcohol rectifying columns with the necessary vent coolers, partial condensers, Calandria heaters, whisky and spirit coolers. The first column only is used when making whisky. Aldehyde and fusel oil, washed and redistilled, are sold as by-products,

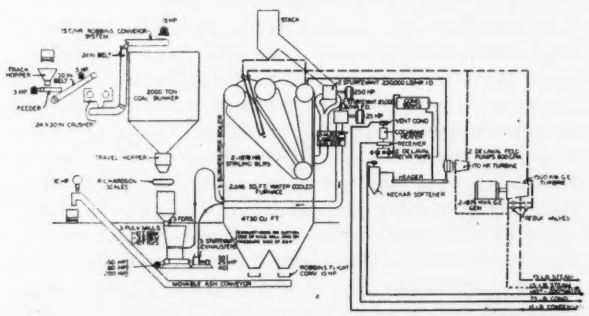


Fig. 4. Flow diagram of the power plant and water softener

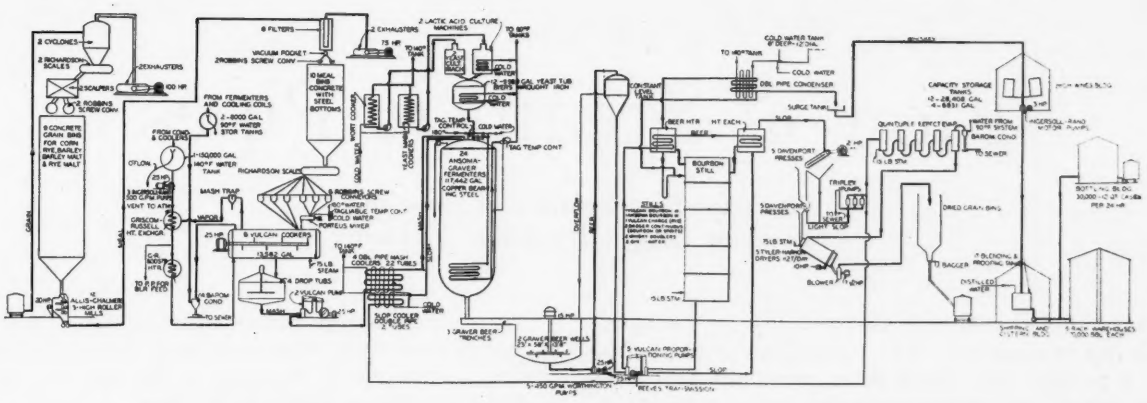


Fig. 5. Flow diagram of the distilling process. Motor sizes are shown to give an indication of the magnitude of the electric loads

the first is used largely for making denatured alcohol, the second in the paint and varnish trade.

Finished products of the still house, all colorless liquids, are then pumped to the high wines building which contains 12 copper tanks holding 28,408 gal. each and four 6831 gal. tanks. These tanks are set off level so they will drain completely. From this building liquors are pumped, by Ingersoll motor pumps, to the shipping and cisterns building which contain copper liquor tanks for gaging, proofing and diluting to standard proof whisky before barreling. After barreling whisky is stored in rack warehouses for aging. Whisky obtains its flavor from the proportion of rye, corn and barley used in the mash but its color comes from the barrel. Fusel oil and impurities are also modified during the aging process. The bottling department with a capacity of 30,000 quart cases per day, has five lines of filling, capping, labeling and cartoning machinery with the necessary glass lined tanks for blending and space for storage of cased goods.

Two of the six contemplated rack warehouses are built, the remaining four will be built as needed. Each of these warehouses has a capacity of 70,000 bbl. of 50 gal. each, giving a final storage capacity of over 20,000,000 gal. upon which the government collects a tax of $2.00 per gal. as it is withdrawn. These warehouses are 11 stories high, one continuous barrel rack from basement to roof, each story 3 racks high. The roof is supported directly on the racks, the walls simply acting as an enclosure.

Pipe lines from the still house and storage tanks must be in triplicate as government regulations prohibit running beverages through the same lines used for spirits and the distinctive flavor of gin stays in the pipes and would taint whisky. All piping that comes in contact with hot mash, beer, or hot slop is copper and pumps are bronze. Wrought iron is used for cold mash, cold beer and cold slop.

Government regulation in the distilling industry is very strict. The product from the time it enters the grain bin until it leaves as bottled whisky is under lock and seal which can be opened only by government inspectors. In the piping carrying spirits or liquor all valves are locked and all flanges sealed by two wires passing through drilled bolts and nuts. Distilleries cannot operate on Sunday nor can commercial spirits and beverages be made at the same time. When changing from one to the other it is necessary to shut down, turn in one permit, take out another and start up again.

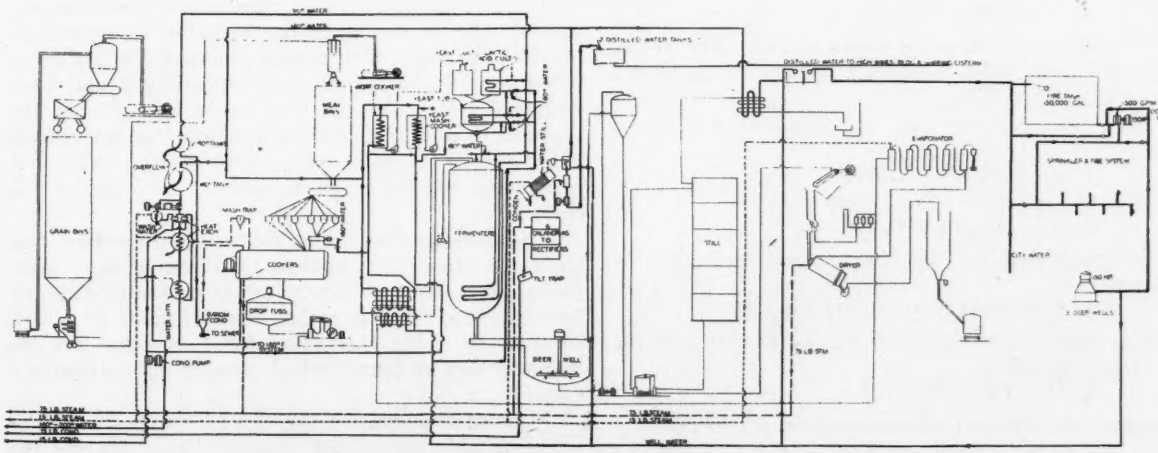


Fig. 6. Flow diagram showing the extensive use made of steam and water in the manufacture of whiskey and spirits

Flow *of* Steam *in* Pipes

Chart for Easy Solution of Flow and Pressure Drop. By Julius Hulman

SELECTION OF PIPE sizes to carry a given quantity of steam with a predetermined pressure drop is a problem for which many equations have been developed, and correspondingly great numbers of tables and charts have been devised.

Equations upon which this chart is based seemed the most logical of any that were used and, as they are a bit awkward to handle, their use is made easier by graphical representation, the accuracy of which is in harmony with the accuracy of the equations used.

Before the chart itself is discussed it will be best to explain the underlying equations.

Equations Used

For flow of steam or any fluid in pipes a correct rational equation is:

$$p = (174.2\ f\ W^2\ L\ v) \div d^5$$

Where p = pressure drop in lbs. per sq. in.; f = friction factor; W = lb. steam flowing per second; L = equivalent length of pipe in ft.; v = specific volume of steam; d = internal diameter of pipe in inches.

The friction factor f is the variable upon which the accuracy of the equation largely depends. Recent experiments have proved that f varies as uv ÷ dV. Where u = viscosity of steam in centipoises; V = average linear velocity of steam in feet per second.

An important fact to be noted here is that f is dimensionless, hence can be used in calculations involving any system of units, Metric, English or other.

The equation for f as developed by McAdams and Sherwood from a comparison of data from many experimenters is:

$$f = 0.0054 + (0.375\ uv \div dV)$$

This equation is true for steam and air. For steam, $u = 0.0083 + 0.00002\ t$; where t = temp. of the steam in degrees Fahrenheit.

Then the complete set of equations for steam flow is:

1. $u = 0.0083 + 0.00002\ t$
2. $f = 0.0054 + (0.375\ uv \div dV)$
3. $p = (174.2\ f\ W^2\ v\ L) \div d^5$

In order to simplify the chart, equation 2 may be written:

4. $f = 0.0054 + (0.002044\ u\ d \div W)$

If it is desirable to find V it can be found from the following equation:

5. $V = 183.3\ Wv \div d^2$

A complete equation for pressure drop would read:

6. $$p = \frac{174.2\ W^2 v\ L\{0.0054 + [(0.002044d \div W)(0.0083 + 0.00002t)]\}}{d^5}$$

The only variation in the equation for f when applied to air is in the expression for u. If this term is changed to give values for air, then the pressure-drop equation becomes applicable to that gas.

Discussion of Charts

As a single chart with only one scale for d was a bit puzzling to use and the resulting accuracy was insufficient, the method employed was to make two charts, one solving for f and the other, using the value of f as found in the first chart, to solve for pressure drop.

Charts are so made that in use one starts at the left side and goes straight through to the scale on the right, which gives the answer. The charts are based on a rigidly accurate method of development, any inaccuracy in the result being due to errors in mechanical construction or use.

Use of Charts

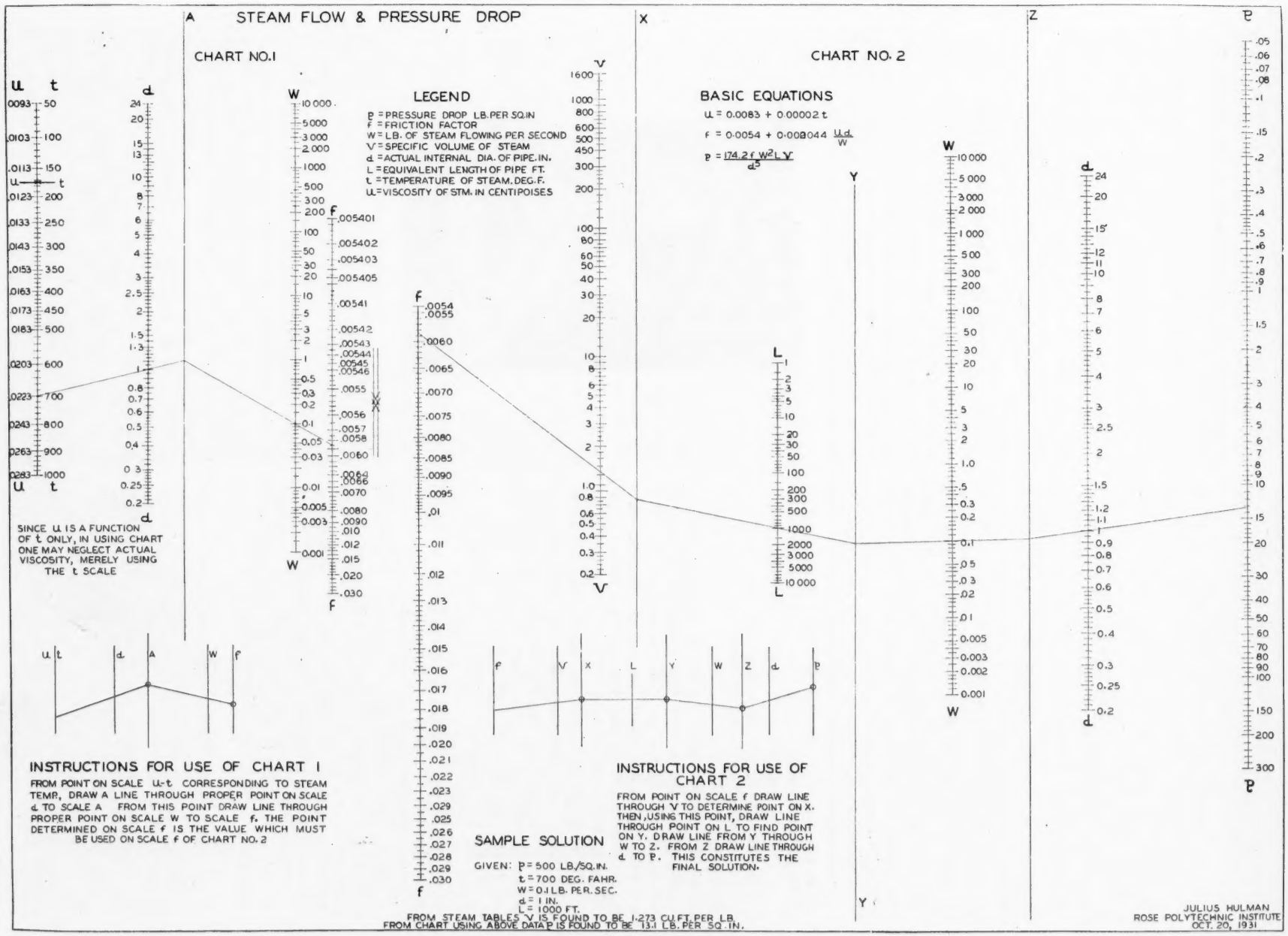
In applying the charts it must be remembered that the initial volume and temperature are used. If the pressure drop is less than 10 or 15 per cent, this is sufficiently accurate. If the pressure drop exceeds 15 per cent, the average pressure must be used to find volume and temperature of the steam, the results thus obtained being accurate up to 40 or 50 per cent pressure drop. Beyond this other equations must be used.

For problems involving wet as well as saturated or superheated steam, use the proper temperature and specific volume; the condition of the steam makes no difference.

This chart is used most advantageously in finding the correct diameter when the other variables are known. To do this with the equation or equations, involves solving a fifth degree equation; or assuming a value of d, finding the corresponding f and then finding d from eq. 3. If this checks closely with the assumed d, well and good; if not, use this determined value for d (or some value between the two) and repeat the process until a value d is found which checks.

The same method can be followed on the chart but, since the effect of a change in d can be seen more plainly, it is easier to determine the necessary changes. Usually, however, f is rather close in value to 0.0054, so that, by using this value for f, a value for the diameter can be found, which usually approximates d closely.

Like all nomographs, the chart involves a scale for each variable and a few dummy lines. To use the chart, lines are drawn connecting two scales and


A
STEAM FLOW & PRESSURE DROP
CHART NO.1
LEGEND
P = PRESSURE DROP LB. PER SQ. IN
f = FRICTION FACTOR
W = LB. OF STEAM FLOWING PER SECOND
V = SPECIFIC VOLUME OF STEAM
d = ACTUAL INTERNAL DIA. OF PIPE. IN.
L = EQUIVALENT LENGTH OF PIPE FT.
t = TEMPERATURE OF STEAM. DEG. F.
u = VISCOSITY OF STM. IN CENTIPOISES
SINCE u IS A FUNCTION OF t ONLY, IN USING CHART ONE MAY NEGLECT ACTUAL VISCOSITY, MERELY USING THE t SCALE
INSTRUCTIONS FOR USE OF CHART 1
FROM POINT ON SCALE u-t CORRESPONDING TO STEAM TEMP, DRAW A LINE THROUGH PROPER POINT ON SCALE d TO SCALE A FROM THIS POINT DRAW LINE THROUGH PROPER POINT ON SCALE W TO SCALE f. THE POINT DETERMINED ON SCALE f IS THE VALUE WHICH MUST BE USED ON SCALE f OF CHART NO. 2
SAMPLE SOLUTION
GIVEN: P = 500 LB./SQ. IN.
t = 700 DEG. FAHR.
W = 0.1 LB. PER SEC.
d = 1 IN.
L = 1000 FT.
FROM STEAM TABLES V IS FOUND TO BE 1.273 CU FT. PER LB.
FROM CHART USING ABOVE DATA P IS FOUND TO BE 13.1 LB. PER SQ. IN.
X
CHART NO. 2
BASIC EQUATIONS
u = 0.0083 + 0.00002 t
f = 0.0054 + 0.0008044 u.d / W
P = 174.2 f W² L V / d⁵
INSTRUCTIONS FOR USE OF CHART 2
FROM POINT ON SCALE f DRAW LINE THROUGH V TO DETERMINE POINT ON X. THEN, USING THIS POINT, DRAW LINE THROUGH POINT ON L TO FIND POINT ON Y. DRAW LINE FROM Y THROUGH W TO Z. FROM Z DRAW LINE THROUGH d TO P. THIS CONSTITUTES THE FINAL SOLUTION.
Z
P
JULIUS HULMAN
ROSE POLYTECHNIC INSTITUTE
OCT. 20, 1931

extended to cut a third line. This is done on the chart, beginning at the left and moving to the right.

Usually the pressure drop, p is unknown, while pressure of steam, t, d, W, and L are known. First, from steam tables find v, corresponding to the given pressure and temperature. Then by a line through values on temperature and d scales determine a point on line A. Through this point and W draw a line to find the value of f.

Now in the second chart, using this value of f, draw a line through values of f and v to find a point on line X. From that point pass through L to a point on line Y. From the point on Y through W to line Z. From the point on Z pass through d to p, and read the answer.

A few sample solutions will more clearly show the method followed.

Problem 1. Steam flows through a 6 in. standard pipe into a condenser at the rate of 500 lb. per hour. The pressure at the condenser is 1 lb. per sq. in. abs. The quality of the steam is 96 per cent. The pipe is 150 ft. in length with one elbow.

1. Condition of steam.

From steam tables, t = 101.9 deg. F.; v = 333.9 cu. ft. per pound at 100 per cent quality and 319 cu. ft. at 96 per cent quality.

2. Pipe length equivalent to elbow is 12.9 ft., hence total equivalent length of pipe is 162.9 ft.

3. 6 in. standard weight pipe is 6.065 in. internal diameter.

4. W = 500 ÷ 3600 = 0.139 lb. per sec.

From the charts, f = 0.0063 and p = 0.134 lb. per sq. in. pressure drop. The pressure at the other end of the pipe is 1.134 lb. per sq. in. If one wished to be more accurate the average pressure of 1.067 lb. per sq. in. would be used.

The temperature corresponding to this pressure is 103.8 deg. F., and the volume at 96 per cent quality is 305.5 cu. ft. per lb. Using these values, p = 0.128 lb. per sq. in. pressure drop and the pressure at the other end of the pipe becomes 1.128 lb. per sq. in.

Problem 2. What size pipe will carry 100 lb. of steam per second with a pressure drop of 5 lb. per sq. in. per 100 ft. of pipe? Steam pressure is 500 lb. per sq. in abs. and temp. is 600 deg. F.

From steam tables, v = 1.16 cu. ft. per lb.

Assume f = 0.0054 and on the right hand chart work from f scale over to Z line; then from the located point and p = 5 lb., the diameter is 11.6 in. From the left hand chart, for this diameter f = 0.005404 so that the value of d is nearly enough correct.

If, however, a 12-in. heavy pipe for 600 lb. pressure is used, with internal diameter 11.5 in. the pressure drop would be 5¼ lb. per sq. in.

Conclusions

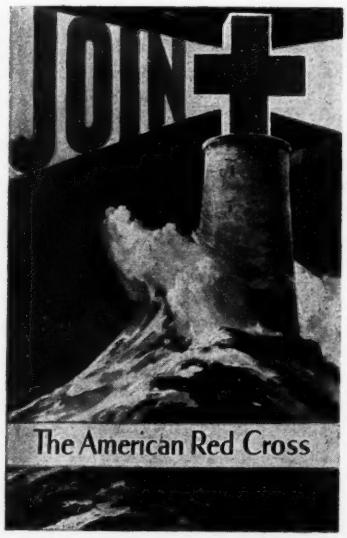
One usual objection to the use of a chart is that its accuracy is insufficient. In this case, however, the friction factor, or rather the equation which enables one to determine the friction factor was derived from a curve drawn through a number of points. Therefore, the limitation of the accuracy of the equation for f is the curve from which it was derived. Knowing this, there is no point in carrying the accuracy of answers beyond the figures as read from a chart such as this.

Besides being convenient and rapid, use of the chart insures the correct decimal place. When using the slide rule or logarithms, one is more liable to make a mistake in the placing of the decimal point than when using the chart.

Another advantage of the chart is that a good conception of the effect of a change in one variable upon the result can be obtained. In the case of a solution for pressure drop, when the point on the scale Z is found, the effect of a variation in d can be easily seen, although, as d changes, f changes somewhat also. The magnitude of the effect upon p of changing d can, however, be fairly well established.

Red Cross Is Prepared to Serve

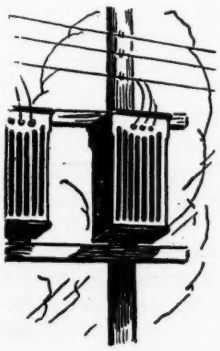
Chairman John Barton Payne, in appealing for generous support, points out the breadth of Red Cross service, which includes instruction in first aid, life saving, home hygiene; nursing registration for the military and Red Cross reserve corps; assistance to veterans and service men and their families; public health nursing, Junior Red Cross and volunteer work.



"Wherever there is human need, there is the Red Cross," said Judge Payne. "Disasters come with little or no warning. The Red Cross helps the victims to places of safety, houses them, feeds them; provides hospitalization and medical attention; helps victims without resources to get back on a normal basis. It very often happens that expert Red Cross disaster workers are at the scene of an approaching storm many hours in advance, so that the community is organized and prepared for it. The United States Weather Bureau and other departments of the government coöperate in giving warning and in affording relief to disaster victims."

To keep at high efficiency the disaster machinery of the American Red Cross, millions of Americans will take out memberships during the organization's annual Roll Call, November 11 to 29. Every Red Cross dollar is friendly and is busy day and night making the world healthier and better.

Load Factor Determines Maximum Efficiency Point of Power Transformers



By
C. F. SHERRIFF

Power Trans. Section
Westinghouse Electric
& Manufacturing Co.

IN THE SELECTION and purchase of power transformers for any particular installation the actual cost of the transformers to the user is the first cost or purchase price, plus the accumulative operating cost. The first cost of two power transformers of *the same rating* might be the same but one of them more costly to operate than the other. It is, therefore, important that the purchaser calculate the probable load factor of the station in which the transformers will be installed and purchase a transformer bank having the most economical efficiencies for such load factor.

The load factor of a transformer station is the average kilowatt load on the station as a percentage of installed capacity over a definite period of time, usually one year. After the purchaser has determined the probable load factor, the transformer manufacturer's problem then is to furnish a transformer having a maximum efficiency point that will as nearly as possible meet the specified load factor requirement for the given transformer rating.

Power transformers of given ratings have very definite economical efficiency levels. As a convenience these efficiency levels may be expressed in terms of the product of per cent iron loss and per cent copper loss. Each rating has its own most economical efficiency level or product of losses. Knowing the product of losses for a given rating and knowing the load factor applying to the station where the transformers will be installed, it then becomes a transformer design problem to build a transformer having an iron loss and copper loss such as to give the maximum efficiency at the point indicated by the load factor.

Transformer losses are grouped as iron loss and copper loss. In the iron loss is included all the loss of the transformer when it is excited but is carrying no load. The iron loss is therefore independent of the load and is a constant at all loads. The copper losses are the result of load current in the transformer windings (neglecting the small copper loss due to the magnetizing current in the primary winding) and so they will vary as the square of the load. Thus, at no load there is no copper loss; at 100 per cent load there is 100 per cent copper loss; at 75 per cent load there is 56¼ per cent copper loss; and at 50 per cent load there is 25 per cent copper loss.

With a given product of losses, the designer can design his power transformer with the proper ratio of copper loss to iron loss to obtain the maximum efficiency point where desired. In doing this, however, there are certain limits beyond which it is uneconomical to attempt to place the maximum efficiency point. In general, these limits are 60 per cent full load and 80 per cent of full load, except in cases where very special transformers are required.

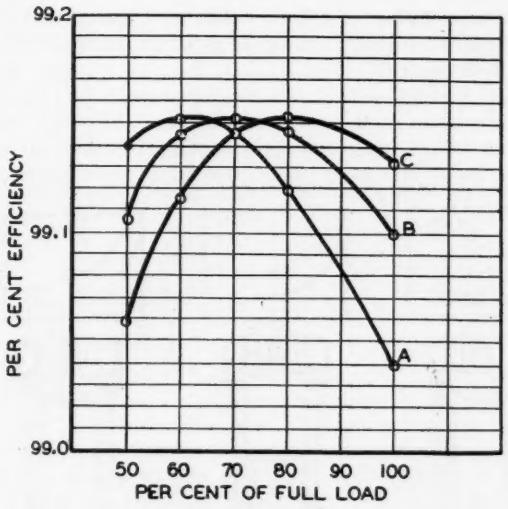
As an example, a 5000-kv-a., single phase, 60-cycle, 55 deg. Centigrade rise, 115,000 v. standard power transformer might have a product of losses of 0.182. The ratio of copper loss to iron loss to obtain the maximum efficiency at 60 per cent full load is 2.75 to 1. Applying this ratio, the per cent iron loss and per cent copper loss is obtained as follows:

$$\sqrt{0.182 \div 2.75} = 0.257 \text{ per cent in iron loss—and}$$

$$\sqrt{0.182 \times 2.75} = 0.708 \text{ per cent copper loss}$$

These present losses can be checked by multiplying them together to obtain the product of 0.182.

With these per cent copper and iron losses it is easily developed that the maximum efficiency is 99.15 at 60 per cent of full load. In a like manner, if the purchaser's load factor indicates that maximum efficiency should be at 80 per cent of full load, a ratio of copper loss to iron loss of 1.56 to 1 would be required. Following through the same calculations as given above, it is found that the maximum efficiency is 99.15 at 80 per cent of full load.



Transformer efficiency curves

The three curves shown give a clear illustration of what has been proved in the example. Curve (A) is the efficiency curve for a transformer having maximum efficiency at 60 per cent load; Curve (B) is the same transformer with maximum efficiency at 70 per cent load; and Curve (C) the same transformer with maximum efficiency at 80 per cent load.

Power Generation *by* DIESEL ENGINES

Introduced at the Beginning of This Century, the Diesel Engine Quickly Found Its Place and Today Enjoys Ever Increasing Popularity

ALTHOUGH only about 35 yr. old the Diesel engine ranks high in popularity as a prime mover due largely to its inherently high efficiency, reliability, simplicity and flexibility. In general the thermal efficiency of a modern engine will run around 35 per cent with a desirable flat fuel consumption characteristic from a third or half load to full load and with comparatively little variation from units ranging from a few up to several thousand horsepower.

Fundamentally the Diesel is a self ignition engine, air being rapidly compressed by the piston until its temperature is sufficiently high to ignite the fuel as it is injected into the cylinder. As originally conceived by Dr. Diesel in 1892 the engine was to burn coal dust, combustion being controlled so as to give a constant temperature during the combustion period. Gases were to expand isothermally and it was expected that these gases would be exhausted cooler than the atmosphere so that no water jacket was provided on the first engine.

Commercial considerations, however, led to certain modifications of the cycle and design. Although later developments led to successful utilization of coal and other industrial waste dust, the main development of the Diesel has been for the utilization of oil, injected so as to give constant pressure during combustion and with water jacketed cylinders.

Normal exhaust temperatures range around 600 to 750 deg. F. and an approximate heat balance shows roughly one third of the heat of the fuel as useful work, one third lost in the jacket cooling water and one third lost in the exhaust gases. Utilization of this waste heat to raise the overall efficiency of the plant has been attempted with some success, using boilers to heat water or generate low pressure steam which may be used in heating systems or for generation of additional power[1].

Early engines were heavy, weighing several hundred pounds per horsepower but recent developments and utilization of alloys have reduced this considerably. Large standard slow speed engines today are built around 90 lb. per b.hp.[2], small high speed engines, 13 to 20 lb. per b.hp..[3] and aeroplane engines 2½ lb. per b.hp.

[1]Waste Heat Recovery from Internal Combustion Engines, by H. F. Shepherd, Power Plant Engineering, Feb., 1934, p. 103.
[2]Details of the Country's Largest Diesels at Vernon, Power Plant Engineering, March, 1934, p. 143.
[3]Power Plant Engineering, Crankless Diesel, March, 1934, p. 155 and Opposed Piston Diesel Engine, July, 1934, p. 346.

Fig. 1. Admission stroke. Piston travels down filling cylinder with air

Fig. 2. Compression stroke. Piston travels up, compressing air

Fig. 3. Power stroke. Fuel injected and piston travels down doing work

Fig. 4. Exhaust stroke. Piston travels up exhausting burned gases

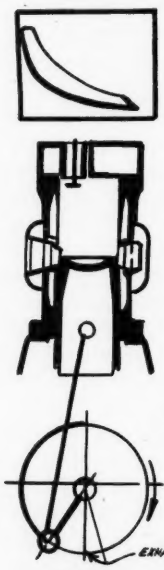


Fig. 5. Compression stroke. Piston travels up covering exhaust ports

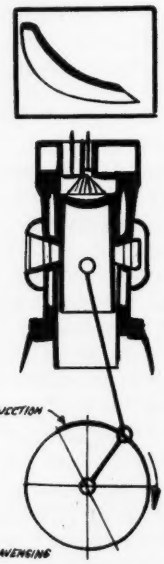


Fig. 6. Power stroke. Piston travels down uncovering exhaust ports

Engines can be classified in many ways according to the number, arrangement and design of cylinders, the method of fuel injection, method of lubrication, etc., but probably the most fundamental method is according to the method of operation as all engines fall into one of two groups, four cycle or two cycle.

Principles of Operation

These terms are contractions of the more accurate four stroke cycle and two stroke cycle indicating the number of strokes the piston takes for each cycle or power impulse. The four stroke cycle is shown by Figs. 1 to 4, the corresponding portion of the indicator card being shown by heavy lines for each stroke of the piston. During the first stroke, Fig. 1, the admission valve is open and the piston travels downward filling the cylinder with air. On the second stroke, Fig. 2, the admission valve closes and the piston travels upward compressing the air to around 500 lb. per sq. in. Just before top dead center fuel is injected, Fig. 3, and, due to the high temperature of the compressed air, ignites.

As it requires an appreciable period of time for the oil spray to be heated up and start burning, injection takes place sometimes 10 to 15 deg. before dead center so that useful pressure is exerted on the piston as soon as it starts downward. The duration of the flat, constant pressure part of the diagram is a function of the length of time required to inject the full fuel charge. After combustion stops the gases expand and force the piston downward. This is the power stroke. Near the end of this stroke the exhaust valve opens and the piston moving upward, Fig. 4, forces out the burned gases. The admission valve then opens and the entire cycle is repeated. The automobile engine operates on a four stroke cycle.

Two Cycle Engines and Supercharging

In the two stroke cycle exhaust valves are eliminated, the gases of combustion passing out of ports in the cyclinder which are uncovered by the piston near the end of its stroke. The construction is similar to a uniflow engine. After the ports are uncovered, the admission valve opens as in Fig. 5, further blowing out or scavenging the cylinder of burned gases. Shortly after the piston starts its upward travel the exhaust ports are covered and the admission valves are closed. The air thus trapped is compressed and fuel is injected, Fig. 6, near top dead center as with the four cycle engine. At the end of the power stroke the exhaust ports are uncovered and the cycle is repeated. All steam engines operate on a two stroke cycle.

In some two stroke cycles all air valves in the cylinder are eliminated[4] by the construction shown by Fig. 10. Exhaust ports on one side of the cylinder are slightly higher than the scavening ports on the opposite side of the cylinder. The piston traveling downward uncovers first the exhaust ports then the scavenging ports. As the exhaust ports remain uncovered after the air ports are closed it is obviously impossible to get more than atmospheric pressure in the cylinder at the start of compression.

[4]For a complete discussion of the two cycle engine development and scavenging effectiveness, see Scavenging of Two Cycle Diesel Engines, Power Plant Engineering, July, 1934, p. 338.

Adding another set of ports with auxiliary valves as in Fig. 7 enables the cylinder to be charged at full scavening pressure, sometimes called overcharging. As the power of the engine varies with the amount of fuel that can be burned in the cylinder and this is a function of the weight of air in the cylinder, it is obviously advantageous, for maximum power, to have the air pressure as high as possible at the beginning of compression. If the final charging air pressure exceeds the scavening air pressure, it is termed supercharging. Such an arrangement is shown by Fig. 8.

During the period between the covering of the exhaust ports and the upper air ports an auxiliary valve is opened and higher pressure air is admitted to the cylinder. From theoretical considerations a two cycle engine having twice the number of power strokes of a four cycle engine of the same size should develop twice the power. Practical considerations reduce this to about one and one half times in practice. Due to somewhat the same reasons a double acting engine, Fig. 9, does not develop twice the power of a single acting engine.

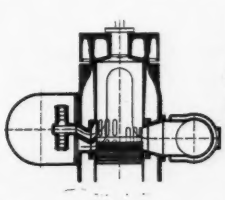


Fig. 7. Double ports and automatic valves allow the cylinder to be charged to full pressure

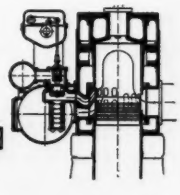


Fig. 8. Mechanically operated valves for supercharging cylinder on a two cycle double acting engine

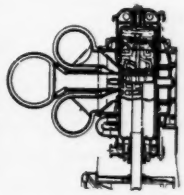


Fig. 9. A two cycle double acting Diesel with four rows of ports, two for each end of the cylinder

Air Compressors

Scavening air is sometimes furnished by a separate compressor cylinder driven from the main shaft and sometimes by a separately driven compressor or blower. Supercharging air may be supplied the same way, one system utilizing an exhaust gas turbine to drive a centrifugal air compressor or blower. Engines using the type of cylinder shown by Fig. 10 often employ the lower side of the piston as a scavenging air blower, two different arrangements being shown by Figs. 10 and 11. The first is known as crank case compression because air sucked in through the valve A, as the piston travels upward, is compressed in the crank case on the lower stroke. The second arrangement is more elaborate requiring a stuffing box on the piston rod. Air sucked in through valves A on the upstroke of the piston is compressed on the downstroke.

Figures 10 and 11 also show another classification often used, trunk piston and crosshead construction. The first engine utilizes a piston with skirts sufficiently long to guide it. The second uses a shorter piston guided by a crosshead. The crosshead is necessary in this case because of the piston rod stuffing box. It is obviously necessary on all double acting engines for the same reason. This particular engine has a crosshead guide on each side but the usual common prac-

tice is to use a shoe on one side only as the pressure on both the upward and downward stroke is in the same direction.

Practically all types of engines are made in single or multiple cylinders. Formerly horizontal construction was used extensively, but vertical construction is now more popular. Some of the new high speed engines are built with V-construction, i.e., the cylinder arranged in two rows making each row set at an angle of about 30 deg. from the vertical making an angle of 60 deg. with each other. Aeroplane engines are commonly made radial. Opposed piston construction is also used. Two designs are shown by Figs. 12 and 13. The second is a vertical engine with the upper piston attached to the crank shaft by a yoke, the first is a new crankless design, with a direct driven scavenging blower.

Fuel Injection

Another division almost as fundamental as the cycle is the method of fuel injection. The first engines perfected used air injection. The fuel charge is pumped up to the spray valve and then blown into the cylinder by a blast of air, at a pressure of around 1000 lb. The compressor, usually three stage with intercoolers, is driven from the main shaft. The arrangement of such a system, complete with fuel pump and compressor is shown by Fig. 14. In solid injection engines, the fuel is injected into the combustion chamber by a fuel pump under pressures of from 1000 to 3000 lb. In the common rail system the fuel pump discharges to a common pressure manifold which is connected to each cylinder in turn through mechanically operated valves. In the individual pump system each cylinder has its individual pump plunger which discharges direct to the cylinder. Governing may be by means of a variable pump stroke or by means of a bypass limiting the period of injection.

Valves are operated from a layshaft or camshaft, driven direct from the crankshaft by gears or silent chain. Engines are commonly started by means of compressed air, the air starting valves usually being operated from the same layshaft with a mechanically interlock to prevent the fuel pumps operating while the starting lever is in position. Details of a modern four cycle solid injection engine are shown by Fig. 15 with the various parts numbered for easy identification.

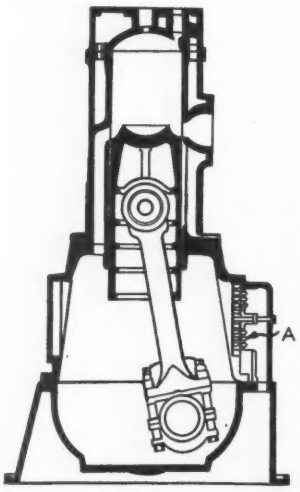


Fig. 10. A trunk piston design with crankcase compression. The lower side of the piston serves as a scavenging compressor

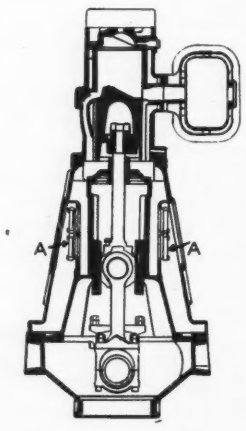
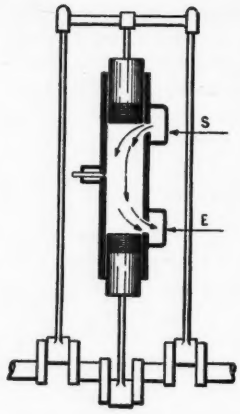


Fig. 11. A crosshead design with piston rod stuffing box. Scavenging air is also compressed by the lower side of the piston



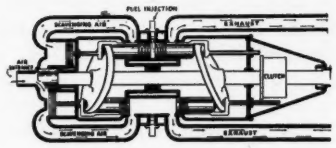


Fig. 12. (Above) A horizontal opposed piston engine built without cranks

Fig. 13. (Left) An opposed piston engine of the vertical type

Starting

Diesel engines are simple and rugged yet they are a highly developed and accurately built mechanism with many of the working parts subjected to extreme pressure and temperature conditions. In order to assure maximum reliability and efficiency they require careful attention. Each engine design differs in detail from the others so that only general operating and maintenance instructions can be given. Operators should study carefully the instruction books issued by manufacturers for their particular engine.

Before starting, the engine should be barred into starting position (some of the large engines have motor driven turning devices) so that the starting air will act effectively on one or more of the pistons. The entire engine should then be inspected; cooling water is supplied to all parts to be cooled with all outlet valves open to insure free circulation. The fuel oil system should be checked to see that the fuel pump suction tank is full and the feed lines are full. Lubricating oil reservoirs should have an ample supply of oil, lubricators should be operating properly and all oil lines full so that bearing surfaces are supplied with oil as soon as the engine starts. Starting tanks should have sufficient pressure to start the engine. Actual starting is usually accomplished by a simple lever or handwheel operation with starting and running positions, the operation itself not differing greatly from that of starting a motor. Sometimes when heavy fuel is being burned the engine is started and stopped on a lighter fuel.

Stopping

Before stopping, the air bottles should be well charged and if the engine is to be stopped on light fuel, the substitution should be made several minutes before stopping so that the heavy fuel will be cleared from the fuel pumps and line. After the load is removed and the engine stopped the fuel pumps, fuel lines and injection air (if used) shut off and the lubricating oil feeds not controlled by the engine operation, stopped. Cooling water should be circulated 10 or 15

min. after stopping or until the engine is fairly cool. Parts of the cooling system subjected to freezing should be drained. The entire engine should be inspected while hot to locate any hot bearings or defective parts.

Running

While running, the engine must be kept well supplied with fresh air, cooling water, fuel oil and lubricating oil. It is good practice to filter the incoming air as all dirt and grit is carried directly into the engine cylinder. Cooling water should not only be ample but should be non-scale forming. Treatment of some kind is almost invariably employed and the water after leaving the engine is commonly cooled by towers and used over. Many plants use a closed system in which

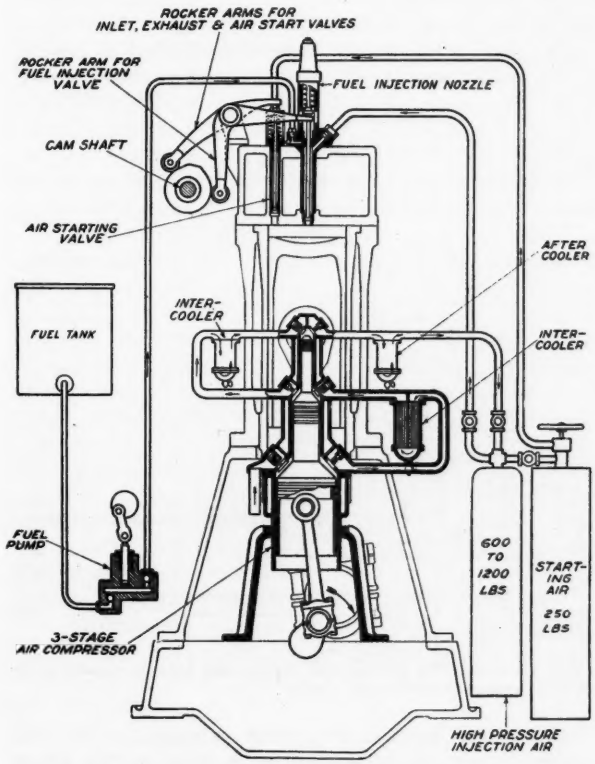
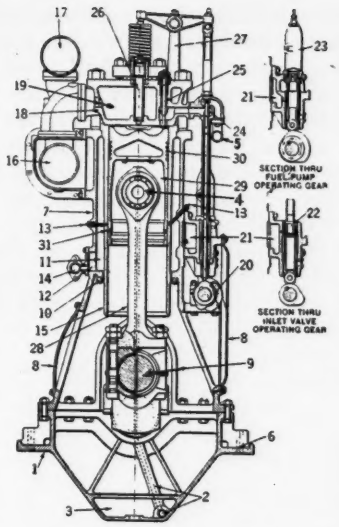


Fig. 14. Arrangement of fuel lines, compressor and air lines on an air injection engine

soft water only comes in contact with the engine parts, the heat picked up in the jackets being transferred to raw water in heat exchangers located in the base of the cooling tower. The temperature of the water leaving the engine usually ranges around 120 deg. F. although the best temperature varies with the individual engine and with the load, lighter load requiring warmer water.

Fuel

Fuels ordinarily used consist of a wide range of petroleum oils either crude direct from the ground or the residue after some of the lighter oils are removed. When purchasing fuel the heating value, specific gravity, sulphur, dirt and water contents should be considered. In general the heavier the oil



1. Base, can be arranged for installation on concrete, steel, or timber foundation. 2. Lubricating oil ducts. 3. Lubricating oil sump. 4. Wristpin. 5. Starting air line. 6. Oil gutter to protect concrete from spilled oil. 7. Frame. 8. Doors, giving access to main and crank bearings. 9. Crankshaft. 10. Watertight sliding joint, allowing expansion and contraction of liner. In some sizes a stuffing box is provided. 11. Water jackets around each liner. 12. Cleaning holes for cylinder jackets. 13. Cylinder lubrication. 14. Cooling water manifold. 15. Removable cylinder liner. 16. Exhaust manifold. 17. Air intake manifold for air supply from from outside or through filters. 18. Cylinder head. 19. Cooling water passage. 20. Camshaft. 21. Oil reservoir from which all push rod and fuel pump tappets are lubricated. 22. Push rod. 23. Fuel pump, one for each cylinder. 24. Air starting pilot valve. 25. Air starting check valve in cylinder head. 26. Spray valve in cylinder head. 27. Valve lever and pedestal assembly. 28. Connecting rod. 29. Piston. 30. Piston rings. 31. Wiper rings, preventing loss of oil from crankcase.

Fig. 15. A modern four cycle solid injection engine with trunk piston

the greater the heat content. Heavier oils are, however, more viscous and usually require heating when handling or when using. High sulphur content usually means corrosion difficulties because of the formation of acid when the exhaust gases come in contact with water. Obviously water and sediment are disadvantageous as both cost money and increase maintenance charges. In general better results are secured by the use of the better or medium grade fuels although many plants are using the cheaper oils, usually with some provision, such as a centrifuge, for cleaning. Records show production from a minimum of 5 to a maximum of about 12 kw-hr. net per gallon of fuel.

Under ordinary operating conditions, the fuel used should burn completely, leaving no residual matter, soot, coke or ash in the cylinders; it should be as clean as possible to prevent clogging of pipe lines, valves and nozzles; at ordinary temperatures, it should flow to the fuel pump; it should be free from water, as water reduces the heating value of the oil, also free from highly volatile constituents that may evaporate at ordinary temperatures; above all, it should have a high heat value.

Ash is probably the most detrimental residue of the burning of fuel oils in Diesel engines, because it wears cylinders and exhaust valves. This ash is extremely hard and is composed of mineral particles, such as quartz, silicate or oxide of iron. These small particles, becoming mixed with the film of lubricating oil, wear the piston and cylinder walls.

Lubrication

Engines are now commonly lubricated by pressure systems through hollow crankshafts and piston rods to the various bearings although some splash systems and ring oilers are used. Cylinders are lubricated at several points by mechanical lubricators. Oil used should be of the best quality and of the proper viscosity for the particular engine on which it is used. Engine builders usually supply a list of several oils

from which the operator may choose. In cold climates with intermittent operation the oil should have a low cold test. It should also separate readily from water, have low acidity and a high resistance to oxidation. Ordinarily this oil is cleaned by filters or centrifuge, some plants filtering the whole batch periodically, some plants filtering the entire circulation continuously and some plants filtering a portion of it continuously. Filters and oil coolers should be cleaned frequently. Consumption of oil is practically independent of the load on the engine and varies directly as the hours of operation. Records show this consumption to vary from a minimum of 1000 to 1500 engine hours per gallon to a maximum of 3500 to 4000.

Air compressor cylinders on Diesel engines are rarely under-lubricated but often over-lubricated. Usually sufficient heat is created during compression to char the lubricating oil unless it lies in a thin film on the cylinder walls which keep it cool. Free oil flows onto the discharge valves where it is burned due to the intense heat, forming carbon deposit. Carbon formation occurs also in the discharge pipes, which are also hot, restricting the air passage and increasing the pressure on the compressor. The oil may pass into and form pockets in the cooling coils.

Moreover, the number of drops of oil which can be secured from a certain amount of any grade of oil varies with the viscosity, temperature, service conditions involved and the diameter and shape of the lubricator orifice. The type and design of lubricator will also affect the number of drops obtained. Varying temperatures of the room will affect the feed of the lubricator and with different types of lubricators the difference in the size of the drops is quite appreciable. Inspection of the wearing surface is, therefore, a better guide for determination of the proper quantity of feed under the prevailing conditions than any other.

Functions of a high grade lubricating oil in a Diesel engine cylinder are as follows: It must form and maintain a complete oil film between the moving parts at all times, replacing metallic friction with a minimum of fluid friction; it must form and maintain a durable piston seal, thereby eliminating blow-by; it must be of such quality that it can be fed in exceedingly small quantities and at the same time comply with the above two items; it must be chemically and physically stable and must resist the destructive action of the heat encountered during the explosion and exhaust strokes; it must not deteriorate and form carbonaceous deposits.

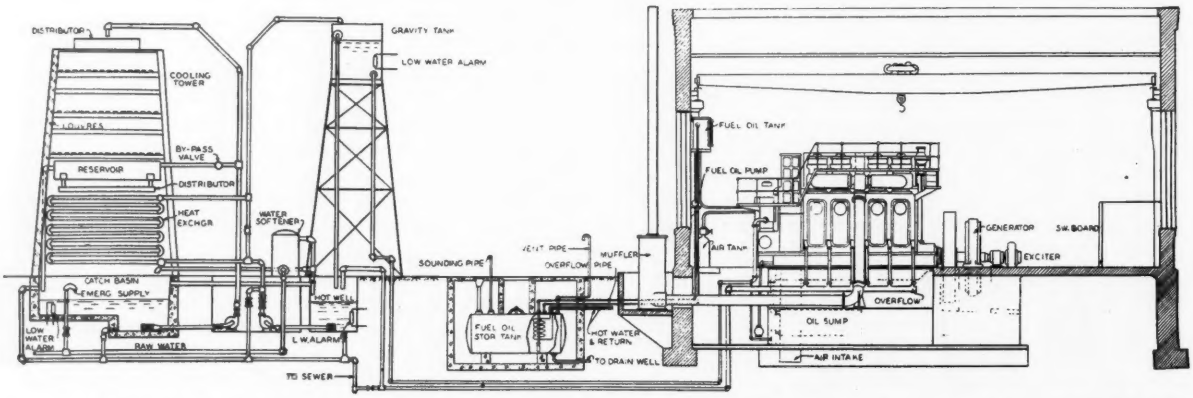


Fig. 16. Layout of a diesel engine station showing cooling tower and fuel oil tank. The gravity tank pumps and hotwell, usually in the power plant proper, have been located in a separate structure for clarity

Proper quantity of lubricant feed cannot be stated generally. It is essential to guard against over feeding. It is a safe rule to use just enough oil to prevent frictional wear and to permit easy and free operation of all parts; more than this will lead to trouble. The discharge valves should, therefore, be examined regularly and the aftercooler, receiver and discharge pipes blown out. This will remove effectively any oil, water or sediment, which may have accumulated. If the discharge valves, upon removal, appear greasy, enough oil has been fed to the cylinders; on the other hand, if the parts appear extremely oily and little pools of oil are found in the compressor pockets or in any of the air lines, oil is being fed in excess of that required.

A general rule is that air compressors are lubricated sufficiently if one or two drops of proper grade oil are used for each 500 to 600 sq. ft. of cylinder surface swept by the piston per minute. This rule, however, must be modified according to the condition of the cylinders and the temperature and degree of compression.

Viscosity has an important relation to the film strength and the resistance to rupture of the piston seal. Viscosity, however, does not in any way represent the lubricating efficiency of the oil as the rate of change of the viscosity as the temperature of the oil increases is even more important, for it is the resistance to change under heat that distinguishes the quality Diesel engine oil from the inferior one. The viscosity of the oil at 100 deg. F. is not a true guide as the viscosity of the oil at working temperatures is what counts.

Maintenance Schedule

Careful operation is necessary, yet with the best care parts wear and maintenance is extremely important. All plants should develop an inspection schedule which should be rigidly adhered to. This of necessity varies with the demands and facilities of the individual plant. The following schedule is used by one of the pipe line companies, a large user of Diesel engines:

A machinist visits each station once a month and

makes a thorough inspection. All maintenance or repair work, except routine changing of oil, cleaning of strainers, and operating procedure, is under his direction. A complete set of valves is provided for one engine and when it is necessary to clean and regrind valves it can be done in but a few hours. Fuel injection valves are reground and reset with an indicator every 30 days, exhaust valves every 60 days and inlet valves every 90 days. Pistons are pulled once each year for cleaning and ring replacement, at the same time the crankshaft alignment and cylinder liner wear are checked.

It is well to keep an extra set of spray valves on hand so that they may be replaced in a short time if necessary. The faulty valves should be cleaned and ground when convenient and kept as spares. Exhaust valve maintenance is usually a major item, cages must be reseated and valves ground and fitted frequently. Fuel pump troubles cause immediate difficulties and these parts, plungers and valves, must be kept tight by grinding and reseating. Leaky starting air valves can be detected by undue heating which can be stopped by grinding in the valves. Even though scale is not present, jackets and water cooled spaces should be carefully cleaned of mud and sludge. The governor is subject to constant wear which should be taken up often. Carbon deposits have a tendency to build up on the cylinder head and should be removed periodically. At the same time the pistons should be pulled, the rings removed, cleaned and examined for wear. All bearings should be kept tight, wear being compensated for by removing shims or taking up on wedge adjustments depending upon the type of bearing.

A more complete schedule follows: 1 mo. periods, spray valves; 2 mo. periods, exhaust valves, relief valves, fuel pump; 3 mo. periods, starting valves, water jackets; 6 mo. periods, intake valves, crank bearings, governor; 12 mo. periods, cylinder heads, pistons, liners, bearings, camshaft, crankshaft, oil pumps.

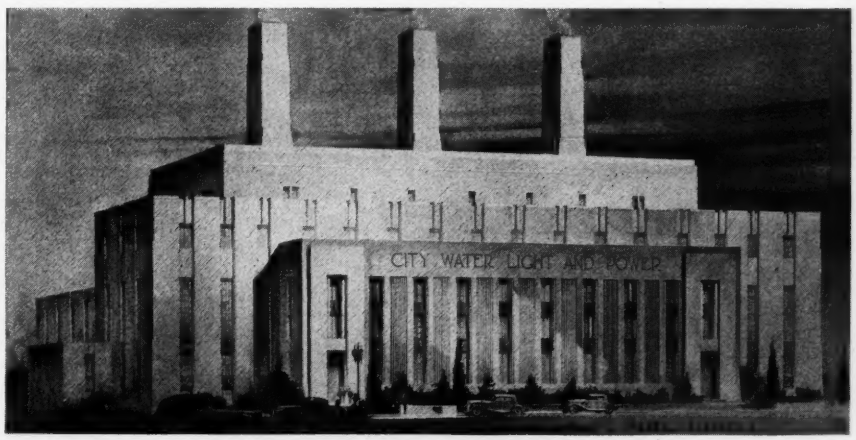
Instruments must not be neglected if best results are to be expected. These should include fuel and lubricating pressure gages and thermometers, water pressure gages and thermometers and last, but extremely important, exhaust gas pyrometers[5] and indicators. Each cylinder should have a pyrometer installed. The usual method being to use a multipoint indicating instrument with a multiple switch so that the operator can switch the instrument from one cylinder to another.

Plant Design

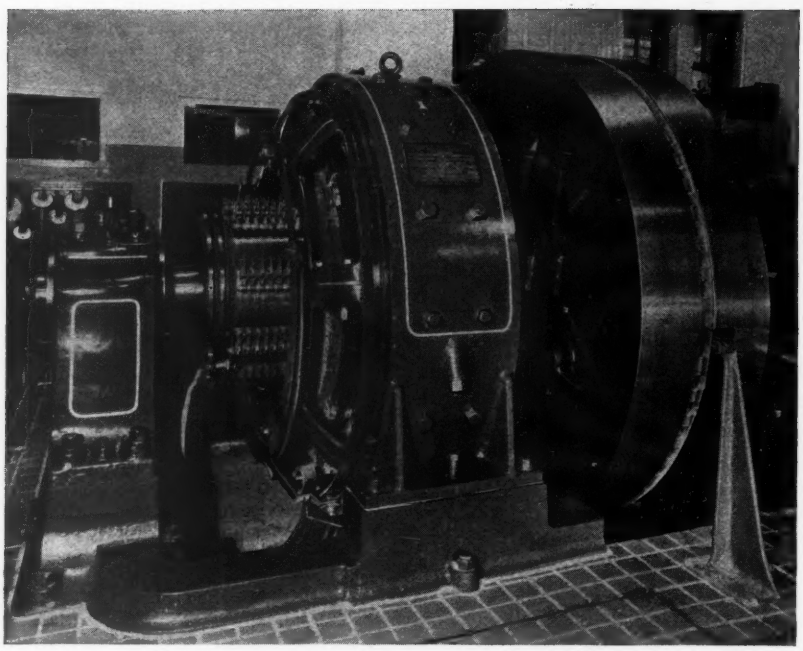
To a large extent the maintenance requirements depend upon the load. Unlike steam engines and turbines, Diesel engines are usually rated at their maximum capacity, and this should not be exceeded. For this reason extreme care should be exercised by the designers in determining the probable load curve. After this is found the selection of proper engine size is comparatively simple as engines are available in any desired size. The problem is simplified because small engines have practically the same efficiency as large units so that two or three units may well be installed to give the desired flexibility. It is desirable to have the average load around three quarters of the engine rating. This gives the best fuel economy and at the same time allows considerable reserve capacity to take care of unexepected peaks.

Careful plant design also takes into consideration necessary and essential auxiliaries which include: fuel oil handling facilities, tanks, cleaners, heaters and pumps; lubricating oil storage and handling and reclaiming tanks and equipment; cooling water supplies, treatment, pumps and cooling towers; air filtering equipment; auxiliary air compressors; suitable building and foundations; operating instruments; switchboard facilities. In cities practically the entire plant must comply with certain building codes and regulations which should be carefully studied before starting construction. In any event the plant should conform to the Underwriters' regulations if insurance is to be carried and safety provisions provided for protection of the operator and equipment.

[5]Diesel Diagnosis with Pyrometer and Indicator, by William Sheffer, Power Plant Engineering, April, 1934, p. 194.



SPRINGFIELD, ILL., is building this power station as part of the new $4,500,000 Lake Springfield water supply. The initial section to house one 110,000 lb. per hr., 400 lb., 700 deg. F. Springfield boiler and one large General Electric Co. turbogenerator, is now under construction. The architectural treatment is unusually good and the station when completed will rank high in the small and select list of really beautiful and distinctive power plants



Instantaneous Voltage Regulation *of* Direct Current Generators*

The Instantaneous Voltage Regulation of D. C. Generators Is an Important Factor in the Control of "Flicker" on Lighting Circuits Subject to Sudden Load Disturbances

IN THE OPERATION of direct current generators, the question of voltage regulation is, as a rule, fairly well understood by the operators of such machines. This voltage regulation is the steady state or normal voltage regulation—the measure of the voltage variation from no load to full load over an appreciable interval of time. There is, however, another type of voltage regulation which is not so well understood but which nevertheless requires consideration in the design of direct current systems and in the operation of direct current machines and that is the "transient" or instantaneous regulation. This "transient" regulation is of particular importance in connection with isolated direct current power plants.

When the load on a generator is suddenly changed (as when manipulating a motor controller or a lighting switch, or when operating a circuit breaker) a voltage drop or rise occurs in the generator. Momentarily this may reduce the terminal voltage almost to zero or increase it nearly to double. These fluctuations may not affect connected apparatus but, even when small, they are likely to have a considerable effect on the illumination given by the lamps which are connected in the generator load circuits. It is in a consideration of these momentary voltage changes that the term transient regulation is employed.

An interesting analysis and discussion of this question was presented recently by T. M. Linville of the motor and generator department of the General Electric Co. in the "General Electric Review," and while his analysis is to a certain extent mathematical, the substance of his discussion as here presented should be of interest to every operator of direct current generators. As a matter of fact, much of the data given apply to the flicker of lamps in general, for as Mr. Linville points out, a.c. generators and a.c. lighting circuits also have the same kind of instantaneous voltage regulation and produce the same type of effect.

Cause of Transient Regulation

The voltage drop or rise occurring on a change in load consists of reactance and resistance components. In a d.c. machine the reactance voltage component

*Abstracted by special permission from the General Electric Review.

disappears quickly with time since the current is continuous. The resistance component and the demagnetizing effect of armature reaction are well understood as factors in the normal voltage regulation. The reactance component, however, is not so well understood and it is with this, the reactance voltage as the chief factor in the transient regulation that we are concerned here.

As shown by Mr. Linville, knowing the inductance and resistance constants of the generator and the load circuits in any given case, it is possible to calculate the various components which make up these transient voltage fluctuations. It is unnecessary to follow through the calculations[1] here but from such calculations a transient voltage curve such as shown in Fig. 1 is obtained. This curve, it will be seen, gives the dip in voltage due to a sudden switching in the load circuit at any time.

While the information given by such curves in regard to the voltage fluctuations is interesting it is of little value unless we know what effect these fluctuations have in commercial circuits. Accordingly, a series of tests were made in which the voltage fluctuations were recorded on an oscillograph and the effect upon the lighting circuits noted by observers. The results of these tests are plotted in Fig. 2. This chart shows the critical magnitude and duration of the voltage dip with reference to the visible flicker of 100 watt lamps as determined by efforts on the part of several

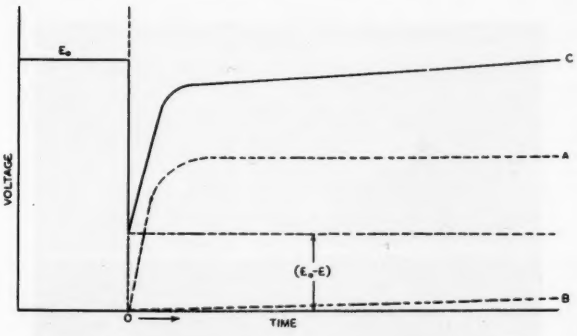


Fig. 1. Transient voltage curve

observers to detect a variation in the illumination. Laboratory tests on circuits of resistance and reactance were also made. Some difficulty was experienced in getting agreement among observers and in finding critical values so that Fig. 2 must not be taken as conclusive. It is accurate, however, for dips in voltage of 75 to 100 per cent.

It was discovered that voltage fluctuations of less than one per cent of normal voltage were not noticeable. Therefore, the duration of any fluctuation was taken as the time during which it exceeded one per cent and the figure is plotted with coördinates of per cent fluctuations and the time for recovery to 99 per cent of the initial voltage.

[1]Those wishing to follow out the calculations may do so by referring to the equations given in the original article on p. 318 of the July 1934 General Electric Review.

In order to determine the maximum inductance a generator can have to permit the switching on of a given resistance load (which causes 100 per cent voltage dip) without flicker. This can be calculated by formulae which Mr. Linville derives. For example, he shows that if the sudden kw. load is 50 per cent of the rating, then the inductance of the 250 v. generators listed below must be less than the values listed:

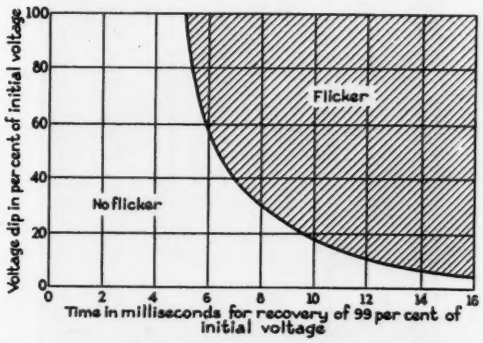


Fig. 2. Allowable Voltage Disturbance on 100 watt Mazda Lamps The data hold only for voltage dips from which the recovery is exponential

Kw.	Inductance in Henrys
50	0.00272
100	0.00136
250	0.000544
350	0.000388
500	0.000272

These values are considerably lower than those for ordinary incompensated generators.

The speed of compounding in compound machines, naturally is of importance in considering this question of transient regulation but regardless of the rapidity or slowness of compounding the conclusions regarding these values of maximum inductance are definite. However, because of slow compounding, a generator whose inductance is satisfactory may still give flicker because the voltage falls short of full recovery. Unless some provision is made to eliminate the magnetic coupling between the series field and the shunt field the voltage in a compound machine will not recover completely but will stop at a value corresponding to $E—R_g\Delta I$, in which E is the instantaneous dip from E_0 the initial voltage and $(R_g\Delta I)$ the voltage drop due to the sudden increment of current I as shown in Fig. 3. R_g is the resistance of the generator.

It is safe to say that any normal generator, whose inductance is less than the values given and when

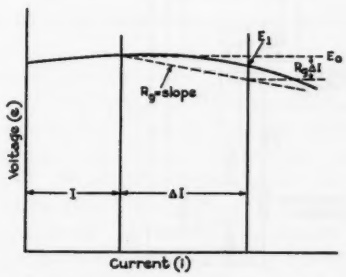


Fig. 3. Static voltage regulation curve of a compound wound generator

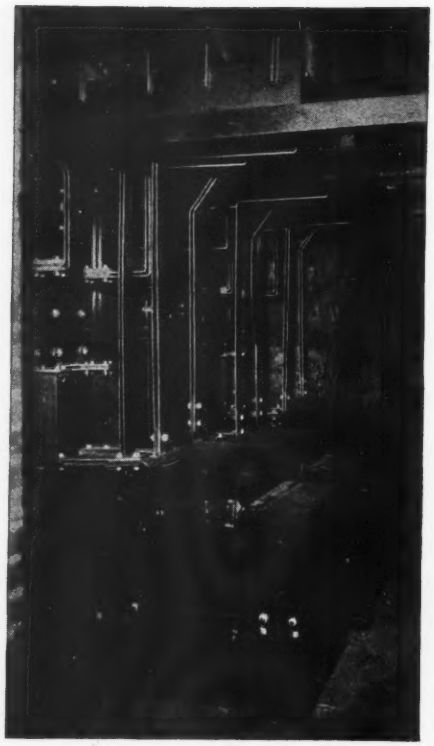


Fig. 4. Stabilizing transformers. The one in the foreground operates with the generator shown in the illustration at the head of this article, a 250 kw. 8 pole 125/250 v. machine

$R_g \triangle I$ does not exceed one per cent of normal voltage, will give good service in conjunction with a fluctuating power load. This has been demonstrated by many tests with various increments and initial loads both inductive and non-inductive. According to these tests the presence of inductance in the power load reduces the voltage dip sufficiently to nullify the effects of the additional inductance. The foregoing are exceedingly strict specifications in the majority of cases and may often lead to more expensive machines than are justified.

When the maximum sudden fluctuation is not more than 15 per cent of the rating of the generator, or of the combined rating of generators in parallel, there is little likelihood of flicker due to the generator in

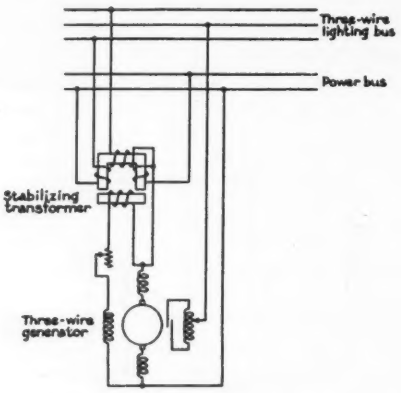


Fig. 5. Connections of stabilizing transformer for use with three wire generator on fluctuating power load

any case. This permits the designer to forget flicker and build the most economical and generally serviceable machine. It should be understood that increments of load of 15 per cent are permissible in rapid succession, several a second being satisfactory. Full load may usually be applied in one second if it is broken up into six or seven increments.

The wording "suddenly applied load" is always indefinite. This can be corrected if the load is thought of in terms of its resistance ($= V^2 \div$ watts, where V is the normal voltage of the generator and "watts" is the load suddenly applied). Thus if the designing engineer desires to apply standard low-cost high-effi-

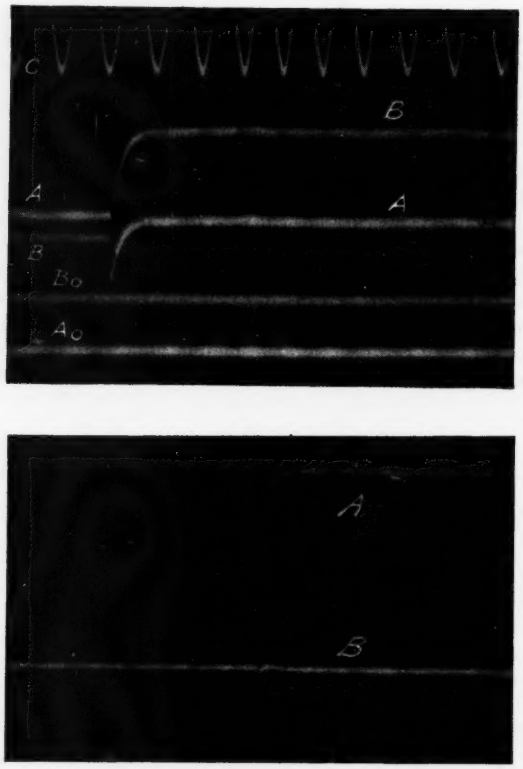


Fig. 6. Oscillograms showing effects of loads applied to generator

Upper: Effect of throwing 500 amp. load on a 250 kw. 250 v. generator carrying 250 amp. initially.
Curve A: Generator Voltage.
Curve B: Armature Current.
Curve C: 60 cycle wave.
Lower: Effect of same load on the generator with stabilizing transformer connected.
Curve A: Generator Voltage
Curve B: Three-wire Lighting Bus Voltage to Neutral.

ciency generators, he can be sure that the lighting service will be satisfactory if no starting device has an initial resistance less than $\frac{100}{15}$ times the rated load resistance and does not draw more than 15 per cent, increment or decrement, of the rated generator current in any one step. The rated load resistance is, of course, the rated voltage divided by the rated amperes. Rated values are those of the generator or the total of the individual ratings when a number of generators are in parallel.

Inductance of the cables to the generator may do

more to produce unsatisfactory lighting than anything else if these are sheathed in iron conduits. In such cases they should be transposed or run through terra cotta or nonmagnetic piping. Cable inductance and resistance should be added to the generator quantities to estimate the bus regulation.

Use of Stabilizing Transformer

In Fig. 4 a bank of stabilizing transformers are shown, the one in the foreground being applied with the generator in the headpiece. This application was made with standard generators in a case where the requirements were severe. The connections of the transformer are shown in Fig. 5. This device neutralizes the magnetic induction between the series and shunt fields, making the compounding fast. It is possible to overneutralize and momentarily overexcite the shunt field, forcing the compounding in spite of the damping of the eddy currents in the solid frame.

The magnetic inductance between the power circuit and the lighting circuit provides a kick in the latter which neutralizes the reactive voltage drop (or rise) in the generator. Therefore, the voltage of the lighting bus is constant regardless of dips and peaks of the voltage at the generator. In Fig. 6, oscillograms of the voltage at the generator and at the lighting bus are shown. These were taken when a switch was suddenly closed on a 500-amp. load of grid resistors, connected to the power bus. The lighting bus was carrying a 250-amp. load simulating the worst operating condition. (The saturation of the transformer was most severe with this loading hence it was a condition determining the physical size of the transformer.) This device was found to give satisfactory results. It requires careful but simple adjustment in a normal case and its construction must be heavy and strong so that the adjustment, once made, will be maintained.

Better Service

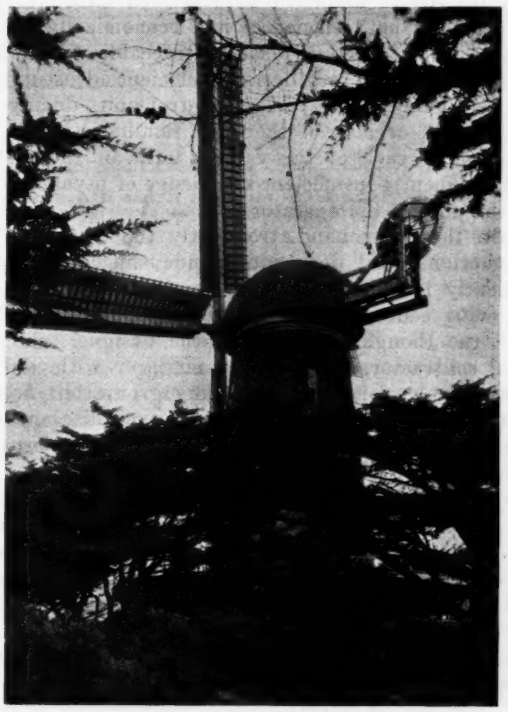
It is evident from this brief discussion that this question of transient regulation is one that is well worth considering since by doing so and applying proper corrective measures it is possible to improve the service where lighting loads are involved. In the original paper, Mr. Linville presents the method of analysis and shows how the transient performance can be predetermined by calculation with great accuracy. Since these analyses are quite mathematical they have been omitted here but those interested are referred to the original paper. Our purpose in presenting this abstract here is to direct attention to the importance of this matter and to indicate how it affects operating conditions.

In a sort of off-hand manner the report of the New York Steam Co. stated that in 1933 that company produced 11,430,339,000 lb. of steam. The figure means little because of its many digits but it can be visualized as follows: That much steam when condensed into water would fill a trough 11½ ft. wide, one foot deep, and 3000 mi. long. In other words, it would extend from New York to San Francisco. Now if you want to expand that water into steam, go ahead. Considerable steam!

Wind Power in San Francisco's Golden Gate Park

In San Francisco the first power there is any record of was furnished by windmills, their use being to raise water. Sam Holladay, the pioneer lawyer, who successfully defended against the city his title to his homestead on Lafayette Square, kept a windmill on his place. The Spring Valley Water Company operated a windmill at its reservoir on Clay and Jones streets in early days. Back in 1850, months before California was admitted into the Union, a windmill whirred noisily over a small building near the San Francisco water front. It provided the motive power for the city's pioneer coffee plant, established by J. A. Folger early that year. The windmill was all right as long as only one machine was needed, but the business soon passed that stage and a steam engine was set up to drive many machines. And, the windmills in Golden Gate Park are historical.

Near the Pacific Ocean, but tapping an underground supply of fresh water, are two immense Dutch windmills which furnish the water for the lakes and irrigation of Golden Gate Park. The southern windmill



One of the Windmills in Golden Gate Park

is the largest in the world, pumping 40,000 gal. of water an hr., while the northern mill has a capacity of 30,000 gal. an hr. The southern windmill has wings 114 ft. across, and the northern one wings 104 ft. across. The Dutch windmills make an Old World scene that has drawn many New World visitors to the Park. Because of the water pumped by these windmills hundreds of varieties of plant life from all parts of the world flourish here in the open air, paying their graceful tribute to the climate of San Francisco.

Satisfactory operation of air conditioning systems requires the concerted action of designer, contractor, erector and plant operator

Operating and Servicing AIR CONDITIONING SYSTEMS

By R. B. Reagan

FAILURE to maintain a prescribed effective temperature, both efficiently and economically within a conditioned area is usually traceable to: Faulty pressure or volume regulation, inefficient adjusting and setting of any of the various control units during the test period, or lack of thorough familiarity with the function of each of the various units of the system and, frequently insufficient knowledge of psychrometry on the part of the operator.

On the other hand, frequently the design is too conventional and does not include sufficient or conveniently located control devices. Consequently, the following code of "Do's and Dont's" were compiled with the thought of assisting the designer, erection man, contractor, or operating engineer without intimating lack of knowledge to any group, but hoping that, by concerted efforts by each, many discrepancies can be minimized or eliminated by having a broader acquaintance with the other fellow's part in the project.

Any air conditioning system of the central station type may be conveniently segregated into three equally important units, namely: The apparatus for cleaning and treating the air. The distribution system including the fan. The control equipment. Therefore, to expedite referencing, this discourse will dwell upon these components individually.

Apparatus

Previous to starting any of the mechanical equipment, a thorough check of all such units should be conducted to determine if pumps and fans and their drive motors have been properly set, the current, fusing and characteristics agree with the manufacturer's ratings, bearings oiled and free of foreign matter. Following this procedure, it is advisable to run each unit at slow speed for a few hours in order to work in the bearings.

The washer or conditioning unit itself, including baffle and eliminator plates, should be thoroughly washed out (the tank should have been tested for water tightness previous to cork encasement). Also, pump suction strainer or pot strainer should be carefully cleansed, as a small stick or rag can cause undue annoyance if drawn into the stand pipes or spray heads.

If air filters are included in the installation, they should be checked in accordance with the manufacturer's recommended instructions as furnished with the particular type unit.

Dampers, air motors and their respective interlocking should be oiled and tested as to ease and unison of operation.

Thorough atomization throughout the conditioning chamber is very important and must be maintained, otherwise untreated air stratification will result. Recirculation pumps are usually not of the self priming type, therefore a check valve should be mounted in the suction line assuring enough water to prevent an air lock when the pump starts up. Should a pump become air bound, it is necessary to open the vent cock on top of the impeller casing, or provide a means of priming. A pressure gauge should accompany the manual control valves to each spray bank, otherwise balancing either spray bank becomes tedious. Likewise, an immersion type thermometer should be inserted in the line of pump discharge. Other than the possibility of outlet stoppage or orifice defectiveness, lack of sufficient pressure at the nozzles may be traced to defective suction, excessive bearing leakage, or possible current surges that would cause a reduction in required r.p.m.

Table I indicates the number of gallons per minute that the three most common sized nozzles will deliver when subjected to varied pressures.

In systems that have been in operation for some time, lack of sufficient pressure can usually be traced to worn nozzle orifices which should be replaced by new ones.

Distribution

Like the pump, the fan should be operated at slow speed until a thorough check can be made of general operations. Then at full speed, checking r.p.m., outlet velocity, and volume, the latter determined by fairly accurate recordings of an anemometer made in the usual manner. And comparing these findings with catalog ratings. Following such a test, proceed to adjust and set the various volume and mixing dampers so as to attain the required air delivery or it may be necessary to vary the fan speed to suit conditions.

Distribution system or ductwork is ordinarily carefully planned, and if properly erected, substantially hung and braced, including long easy sweeps of the proper area throughout, having canvas connections interposed at connection of both fan inlet and discharge, butterfly dampers omitted in favor of deflector dampers hinged on one side with the blade facing the air stream, and, also, if branch dampers having a trunnion and locking device located at accessible points are included in both supply and return conduits, the operator should have little difficulty in attaining the prescribed allocation of air dispersion.

Damper blades should always be mounted horizontally, otherwise ball thrust bearings are necessary, i.e. when mounted vertically. Volume dampers, used to regulate by-passing, should not close tight but be so adjusted that when in closed position, they still pass 50 to 65 per cent air.

Air motors are usually of the gradual acting type, i.e. start to operate at 7 lb. and are fully open at 12 lb. although springs having different tension to vary the operating range are applicable. Of course any motor can be so attached as either to open or close the companion damper with an application of air pressure. Table II shows the proper sized air motors to be selected to operate louvred dampers of various square footage.

Accurate plans of actual construction, particularly when the ductwork is concealed, should be filed with the owner for use of the operator, indicating all details of the installation, such as remote manual damper controls, pipe line valves,—designated by numbered tags, also the capacity, r.p.m. and other general characteristics of all mechanical equipment.

The new type high pressure multi-ribbon orifice outlets should always have deflecting vanes located at the rear of the grille plate, and incidentally, a real improving asset to any type outlet, providing the slight additional cost can be afforded.

Control

No matter how "tricky" a control hook-up may appear at first impression, the function in general is simply that of coördinating control of dew point with returned air temperature, the admixing of the correct amount of outside air—if needed—and maintaining the proper pressure. Naturally such a system should be fool proof and as near mechanically perfect as possible, but it is questionable as to the feasibility of absolute automatic control, for the reason that with the burden of maintaining conditions thrown upon the operating man, more intimate contacting with the conditioned space will result and very often tend to promote more efficient and economical operation by maintaining a physiological comfort rather than those prescribed by maximum guarantees.

It has been the usual custom to locate the room thermostat mounted on the wall at, or about eye level. This is utterly wrong, as recent tests have proven, because, as room occupants are usually seated in a zone, the center of which is approximately 2½ ft. above the floor. Actual recordings of room temperature divulge a variation of from 3 to 8 deg. difference in temperature between 2½ ft. and 5 ft. above the floor, sufficient proof of why people continually persist in resetting the room thermostat. The remedy is obvious—locate the thermostat down nearer the floor in the zone of 95 per cent occupancy.

Table I. Capacity of spray nozzles in gallons per minute
Table II. Air motors

CAPACITY OF SPRAY NOZZLES In Gallons Per Minute					
SIZE	PRESSURE				
	15 lb.	20 lb.	25 lb.	30 lb.	35 lb.
1/4" x 3/32"	.4	.45	.50	.55	.59
3/8" x 3/32"	.67	.78	.87	.96	1.04
3/8" x 5/16"	1.65	1.94	2.17	2.38	2.56

TABLE II

AIR MOTORS		
Size In.	Sq. Ft. of damper each motor will operate	
	Gradual*Acting	Positive Acting
6	6	10
8	10	20
10	20	30
12	40	60

* Thermostatic control is usually considered gradual action, whereas switch or manual control is positive.

Thermostats are built especially suited for the application intended, viz.: with a special water tight stem for insertion into liquids, those with a disc extension for duct application and, the common wall type, any of which may be either direct or reverse acting.

Direct acting instruments deliver a rising pressure to valves or damper motors with an increase of temperature or humidity. Reverse acting instruments deliver a falling air pressure on a rising temperature or humidity, and increase air pressure upon any reduction of temperature or humidity.

Either type has automatic air leak air filter, and operates on a constant supply of compressed air at 15 lb. pressure and has a range of adjustment of 20 deg. F. on either side of the prescribed operating point.

Direct acting type diaphragm valves are normally held in an open position by spring action, and close with an application of air pressure. This type should be installed in the steam or water line to close against pressure flow.

Operating Pressures

Start to close at.....1 lb. air pressure
Be fully closed at.....6 lb. " "
Start to open at.....5 lb. " "
Fully open at.....0 lb. " "

These pressures are those exerted on the diaphragm top, regardless of whether the line pressure is 2 or 150 lb.

Reverse acting type diaphragm valves are spring closed and open with any increase of air pressure. All single acting valves should close against pressure through the valve when used for automatic control. When used as safety valves, as on air or water heaters, they should close with pressure through the valve.

Operating Cycles

Start to open at..... 7 lb. air pressure
Be fully open at....12 lb. " "
Start to close at.....11 lb. " "
Fully closed at..... 6 lb. " "

Adjusting and Balancing

Comfort jobs are usually of the high pressure or low pressure systems. The distinguishing features of each is in the outlet velocity, which in the case of low pressure, amounts to between 200 to 600 f.p.m. and for high pressure, between 2000 and 2500 f.p.m.

Low pressure systems operate with not over 10 deg. F. effective temperature, which is attained by excessive by-passing at the apparatus, whereas, high pressure systems operate with as much as 30 deg. F. differential, with or without return or by-passing.

For either system, the amount of air taken through the conditioner or washer is the most important factor and is measured by anemometer, noting the loss and the temperature between by-passed, conditioned, and fresh air supply. For a system not incorporating by-passing, of course the conditioner capacity must equal the fan demand, plus leakage and friction losses.

In balancing air distribution in a low pressure system, take traverse anemometer reading at each branch duct and compare the average findings with the estimated velocities, volumes, etc. If it is found that some are low and some are high, set dampers or deflectors to correct this condition and repeat until the air flow balance is within 10 per cent correct. Radical changes in capacity should be avoided, otherwise the entire system may be thrown off balance.

For high pressure systems, the balancing should be accomplished by measuring the static pressure at each outlet; here, also, as in the former case, the balancing should be attained first. The total capacity can be rectified later without altering the balance materially.

Occasionally it so happens that fresh air has a tendency to divert around the conditioner by way of the return by-pass, and into the fan, caused by lesser resistance. This may be easily corrected by blocking the fresh air dampers, thereby increasing and balancing the resistance. This procedure is also applicable on other sections of the distribution system to correct unbalanced conditions but care must be given, otherwise the static pressure will increase.

On high pressure systems it is sometimes necessary to reduce the air flow volume. Here, too, there arises the tendency to build up excessive static with a resulting increase of outlet velocity over and above design intentions, tending to produce over-cooling, drafts or noise. To offset this condition, it is necessary to install a static pressure regulator beyond the fan outlet, thereby maintaining at all times a constant pressure regardless of damper adjustments.

The operator's next attention should center about maintaining desired conditions as stipulated by guarantees or occupant's personal requisites, bearing in mind that wet bulb recordings are the critical factors in air conditioning and not dry bulb readings. Therefore, frequent readings with a sling psychrometer of both dry and wet bulb, is strongly recommended. Of course, if an automatic recording device is incorporated, manual readings may be reduced, but not ceased. Owing to the many sources from which deficiences may arise, their correction becomes a matter of elimination. Therefore, if during the cooling season, room temperature rises, check the system for overload by unnoted sources of heat, or possibly excessive infiltration by an open door, or fallacy of an exhaust fan if one is incorporated, the possibility of an over-amount of fresh air being drawn into the system, or any discrepancy of the proper dew point temperature and, lastly, check the room thermostat that is all too frequently exposed to meddlesome room inmates.

In the event there may be a lack of refrigeration, check the suction temperature, also both inflow and discharge temperature and quantity of the condenser; if found to be all right, possibly surface coolers may need defrosting, the machine may require purging or, possibly, an additional charge of refrigerant is needed.

The four basic rules for attaining room requirements are outlined as follows and are offered as a ready reminder list:

Rules for Temperature Correction

(1) To increase relative humidity: Increase the air flow through the conditioner by closing off the by-pass dampers and raise the spray water temperature. Also minimize outside air supply if outdoor wet bulb is high.

(2) To lower relative humidity: Treat the process in reversal as outlined in paragraph (1).

(3) To raise dry bulb temperature: Increase by-passed air volume, reheat the air before entering the fan and, if necessary, include booster heaters located at strategic points in the ducts.

(4) To lower dry bulb temperature: Minimize recirculated air, i.e. close by-pass dampers and thus increase air volume through the conditioner and lower spray water temperature by increasing flow of chilled water to pump suction.

Determining C.F.M. with an Anemometer

$$C\,V\left(\frac{A-a}{2}\right)=\text{C.F.M.}$$

Where: C = Coefficient for correction. Usually 0.97 for velocities below 500 f.p.m., 1.00 for those above 500 f.p.m., and 1.02 for exhaust grilles.

V = Average anemometer readings in ft. per min.

A = Gross area of grille in sq. ft.
a = Net free area of grille in sq. ft.

Describing a Novel Method of Using Current Meters in Measuring the Flow of Water to the Hydraulic Turbines at the Wettingen Power Station on the River Limmat

MEASURING WATER FLOW *in Convergent Intake Sections*

THE QUESTION OF determining the volume of water flowing through large hydraulic turbines during the acceptance tests or at other times is always one that requires careful analysis of conditions. The method used most extensively, perhaps, is by the use of current meters. In addition to the requirement that the flow should be steady it is essential that the flow through the profile should be parallel and that the stream lines cut the measuring cross section at right angles.

Although the conditions for measurements with current meters are generally favorable in both high and low pressure plants, this is rarely so with medium pressure plants. In high pressure plants the measurements are usually taken at a straight part of the pipeline, the current meters sliding on at least two bars arranged on diameters at right angles to each other. In low head plants it is usually most suitable to make such measurements at the intake, where the bottom is horizontal and the sides parallel and vertical.

At medium pressure plants, however, as a rule there is not a sufficient length of pipeline available nor is there a section to be found where the streamline flow is parallel. A typical example is shown in Fig. 1. As can be seen the intakes are convergent and have nowhere a cross-section which is suitable for accurate determination of the quantity of water.

To enable the measuring method with current meters to be retained in principle, Escher Wyss, who supplied the turbines shown in Fig. 1, decided when designing the plant to make provision for using the apparently unsuitable section of the stop log guides for measuring the flow of water. To do this, special precautions had to be taken to compensate for the inaccuracy caused by the very sharp inclination of the flow.

The methods used are interesting and are described in detail in a recent number of the Escher-Wyss News. This plant, by the way, is the Wettingen Power Station on the River Limmat.

For accurate measurement with current meters, the measuring section must be at right angles to the velocity of flow. If this condition fails to exist, the current meters will not give accurate indication of the flow. The difficulty can be overcome by setting the current meter in the direction of the flow *at every measuring point*, and then by calculating the component at right angles to the measuring section. The way this was done at the Wettingen Power Station will now be described.

In this plant there are three Escher-Wyss Kaplan turbines working under a head of 75 ft. and with approximately 1600 cu. ft. of water passing through each one per sec. From the reservoir the water flows through two separate intakes into the common circular section pipe in which the butterfly valves are located. The two intakes are provided with the guides for the stop logs. This is the interesting measuring place. While the two vertical side walls of each

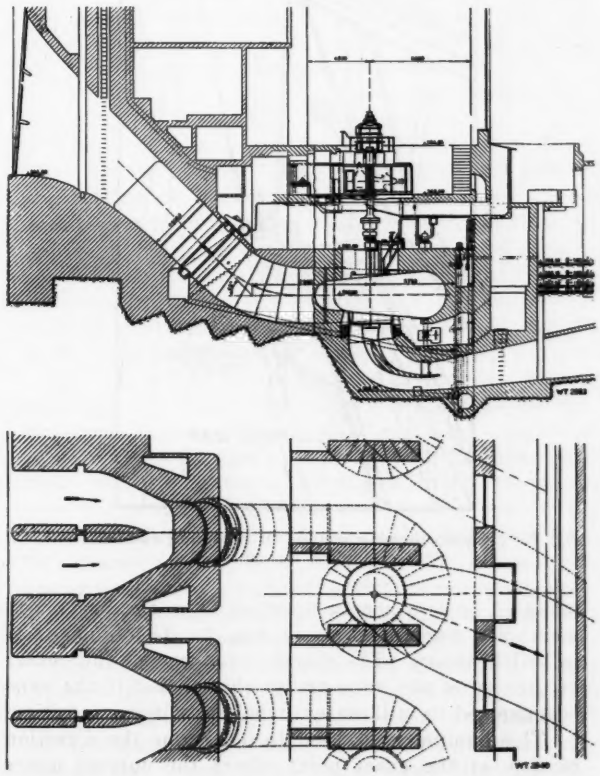


Fig. 1. Cross section and plan of the hydraulic turbine installation of Wettingen Power Station showing convergent intakes

opening are vertical the bottom has an inclination of 22 deg. and the top, 48 deg. Another interesting feature is that the bottom is 56 ft. below the surface of the water and the top 33 ft.

The flow at the intake possesses several features which simplify the measurement. Since the side walls are parallel, it may be assumed that there is nowhere any appreciable component at right angles to these walls. Also it may be assumed that at all points on a horizontal across the direction of flow the angle of inclination of the flow is constant. It is furthermore to be expected that at every point, the direction of flow not only remains unchanged but that it is unaffected by load fluctuations. These assumptions which have been verified have an influence on the installation of measuring equipment.

The equipment used in these measurements was built especially for this installation but similar equipment can be used anywhere.

A measuring carriage was made for each opening in the intakes. This carriage runs on rollers in the guides for the stop logs and carries seven current meters on a horizontal bar of elliptical section. This bar is mounted in ball bearings and is turned by worm gearing which can be operated from above by cables. The arrangement is shown in Fig. 2.

To determine the direction of flow a device was made consisting of a rigid rectangular vane arranged so that it can rotate on a hinge projecting from it and running parallel to the short side. This vane is

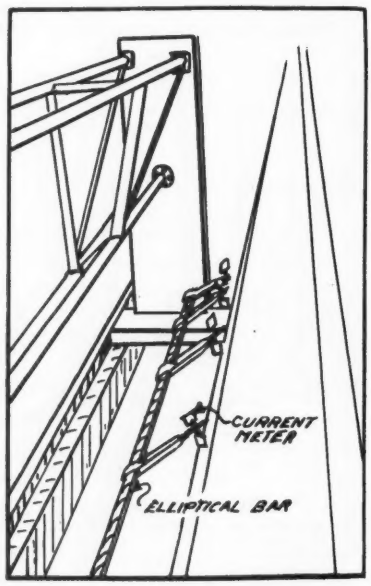


Fig. 2. Diagram showing method of mounting current meters on elliptical section bar

mounted on two arms projecting from the previously mentioned bar as shown in Fig. 3. The hinge rests in ball bearings. The specific gravity and the center of gravity of the vane are so chosen that if the vane is immersed in still water it balances in any position.

This equipment is used to determine the direction of flow at the exact point where the current meter propellers are *afterwards* placed, thus by suitably moving the measuring carriage and turning the bar it must

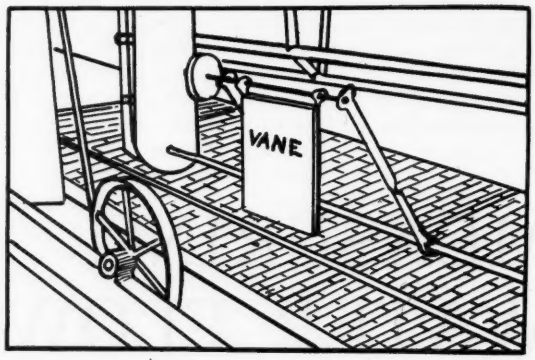


Fig. 3. The vane, mounted on two projecting arms. The electrical resistance device is contained in the round disk at the left of the vane

be arranged that the center of area of the vane is brought to the correct points. To prevent back pressure the vane must be mounted at an ample distance from the two projecting arms and from the bar lying behind them.

It is very important that the angle which the vane makes with the horizontal is correctly transmitted to the measuring stand. This is done by measuring an electrical resistance which is proportional to the angle through which the vane turns. The device consists of a segment of a circle mounted in a water tight casing and which rotates with the vane about its horizontal hinge. The sliding contact is held firm by a heavy pendulum which always hangs vertically. The arrangement is shown in Fig. 4.

The circular shaped resistance has about 12 coils per deg. enabling the angle to be measured very accurately. This resistance is connected in parallel with a normal resistance of equal fineness at the measuring stand. As shown in the accompanying diagram, the

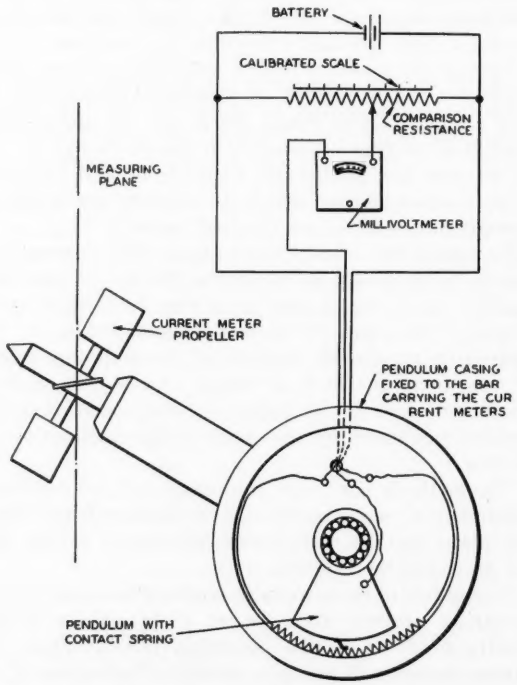


Fig. 4. Wiring diagram showing connections between measuring device and instruments

readings are taken on a millivoltmeter with positive and negative scales, using the Wheatstone bridge method. Tests proved that when steady conditions prevail the position of the vane remains absolutely unchanged and that even when the load alters no variation in the angle of inclination occurs. The assumption that the angle would vary only slightly over the width of the measuring profile was fully confirmed by experimental data. The variations are so small that the corresponding mean value can be immediately assumed for every transverse horizontal.

Angle of Meter Varies with Depth

In accordance with the method of measuring used the measuring points of the current meters do not lie exactly on one vertical plane. Near the top the current meters are set more steeply than near the bottom. The measuring profile is thus a slightly curved surface. It can nevertheless be replaced by a mean vertical plane without great inaccuracy. The vertical planes through the foremost and hindmost position of the propellers only differ in the profile height by about 4 in.

When measuring the width of the profile it was not possible to lay the intake dry so that equipment had to be designed which enabled the measurements to be taken under water. For this purpose a rod which extended on both sides to within 20 mm. of the walls was fixed on the projecting arms. In the ends of this tubular rod spring-loaded plungers provided at their extremities with rollers, were fitted. These rollers were pressed against the walls by the springs. For recording the relative position between the tube and pistons, which was necessary to determine the profile width, sliding contacts attached to the pistons and electrical resistances firmly secured to the tube, were used. For transmitting the position of the sliding contacts to the control stand the same method was used as when determining the angle of inclination of the vane.

Piezometer Calibrated

In conclusion it can be affirmed that this method enables flow measurements to be made with a sufficient degree of accuracy. On the basis of this experience gained in Wettingen, Escher Wyss put the proposal before the Zurich Municipal Electricity Department to carry out the measurements according to this method. Mr. S. Bitterli, a Rheinfelden engineer, was called in as disinterested expert for carrying out the actual measurements; he also supplied the current meters required.

The velocity at entrance to the turbine spiral is comparatively high and therefore also the corresponding increase in velocity. The pressure difference between the spiral and the reservoir can therefore be measured very accurately. During the acceptance tests it was read off on two piëzometers. It is an indication of the quantity of water flowing and can be calibrated by means of the current meters. It is thus possible for every relative position of the guide vanes to the runner blades of the turbine to determine the efficiency in a few minutes. In Wettingen over 100 measuring points could be taken by means of this simple equipment.

Business Trends

Successful business and industrial enterprises are the source of livelihood for all citizens. Business and industry are the means for making and distributing the things every one wants, and therefore for bringing material well-being to the individual.

Industry and business are now not wholly in the hands of employees and management and owners. Others having no interest in industry and business, and little or no experience in either, are claiming the knowledge and ability to direct them and are attempting to dictate the answer to all our problems.

Our government never has operated business efficiently, and inefficient government operation means lower standards of living for everybody. If it becomes certain that the intention of our present government is to take over all business and industry, then employees, management and owners, will have to fight to retain their personal liberty. If such a course should be the intent of our government, "life, liberty, and the pursuit of happiness" would be in jeopardy.

In defining the issue, it is well also to define the aims.

President Roosevelt has stated his aims clearly. He is striving for the health, happiness and security of the people of the United States. In these aims all concur, and to achieve these aims, all enlisted under his banner. Now a year of arrested progress creates doubt of the methods selected by the President and his advisers. It is entirely appropriate that we analyze and criticize, and, if necessary, vigorously oppose any methods, if we believe them unlikely to achieve the President's aims. Particularly must interference with privately owned and controlled business and industry be opposed, if we continue to believe that they are the proper means for achieving the health, happiness and security of the people of the United States.

George P. Torrence.

Tests on a Loeffler boiler at the Vitkovice Mines, made by Professor E. Josse and reported by him in Engineering of London, England, showed that a uniform superheat was maintained from half load to full load by varying the fuel supply and speed of circulation in the boiler and that output could be raised from 2/3 load to full load without change in firing, by increasing speed of circulation, with drop of 54 deg. F. in the superheat.

In this boiler, the entire heating surface acts to superheat the steam in two stages, a radiant type consisting of furnace walls and bottom, and a convection type set in the flue-gas uptake. Evaporation from feedwater, which is heated to 473 deg. F. in an economizer, is in drums outside the boiler by sending part of the superheat steam into the drums. The dry steam from the drums is circulated through the boiler-superheater sections by a pump, the part not needed in evaporating drums being taken off as output, at a pressure of 1840 lb. and temperature of 925 deg. F.

Because only dry steam, free of impurities, is sent through the boiler tubes, it was found that operation was possible with salt concentration practically 90 times as great as is possible in water-tube boilers. No deposit was found in the boiler tubes after 2000 hr. operation.

Construction of Ice Bunkers *for Comfort Cooling*

Details of Construction of Ice Bunkers and Equipment Hook-up for Comfort Cooling by Ice to Give Highest Efficiency

WATER ICE has taken its place alongside of chemical systems, vacuum systems and well water as an important factor when considering the most economical refrigeration for a moderate size comfort cooling installation. Its practicability and economy have been proved over a period of 3 or 4 yr. in many successful installations, consisting of theaters, restaurants, small offices and industrial establishments.

The construction of an ice bunker recommended by the American Ice Co. which has been very active in this field, is shown by Fig. 1. By increasing the length of the bunker and adding a louvre wall, a double duty bunker with a beverage or food storage compartment can be made at slight additional cost.

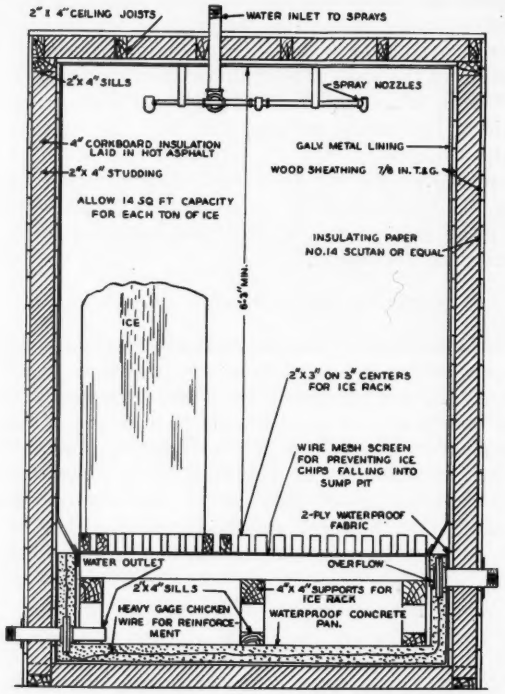

2" x 4" CEILING JOISTS
WATER INLET TO SPRAYS
2"x 4" SILLS
SPRAY NOZZLES
4" CORKBOARD INSULATION LAID IN HOT ASPHALT
GALV METAL LINING
2"x 4" STUDDING
WOOD SHEATHING 7/8 IN. T.&G.
ALLOW 14 SQ FT CAPACITY FOR EACH TON OF ICE
INSULATING PAPER NO.14 SCUTAN OR EQUAL
6'-5" MIN.
ICE
2"x3" ON 3" CENTERS FOR ICE RACK
WIRE MESH SCREEN FOR PREVENTING ICE CHIPS FALLING INTO SUMP PIT
2-PLY WATERPROOF FABRIC
WATER OUTLET
OVERFLOW
2"x4" SILLS
4"x 4" SUPPORTS FOR ICE RACK
HEAVY GAGE CHICKEN WIRE FOR REINFORCEMENT
WATERPROOF CONCRETE PAN.

Fig. 1. Details of a substantial ice bunker for a comfort cooling system

Water Circulated by Pumps and Controlled by Thermostats to Give Most Effective Results

Piping and equipment arrangement in a typical installation with the air cooling unit located at the same level is shown by Fig. 2. If the air cooler is overhead the spray pump and equalizing line can be eliminated because the warm water can be returned from the cooler by gravity, entering the system as shown by the dotted line at A of Fig. 2. Control of temperature of the water in the bottom of the bunker is by means of thermostatically controlled by-pass valve actuated by the temperature in the discharge of the air cooled circulating pump. When the temperature gets too cold some of the return water is by-passed directly to the sump. Excess water is drained from the system by a float valve operating a drain from the warm water return so that the over-flow wastes a maximum amount of heat. In case the float valve does not operate, an open over-flow to the sewer is provided at a slightly higher level.

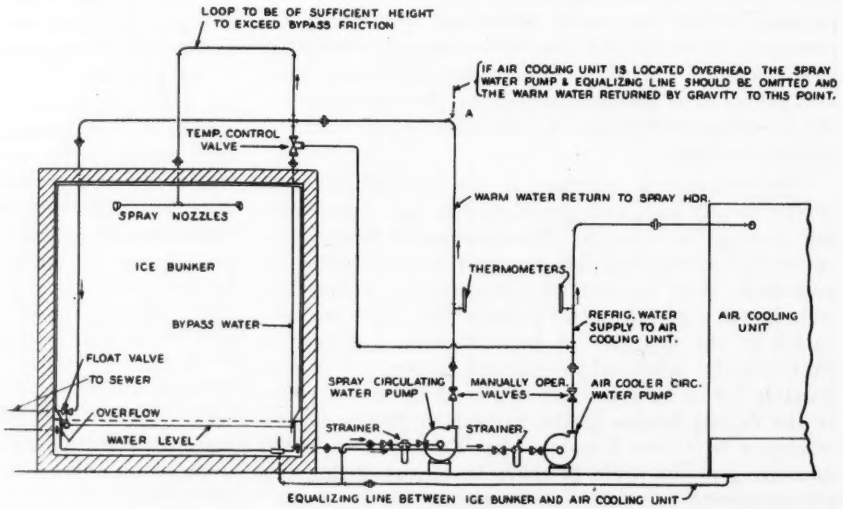

LOOP TO BE OF SUFFICIENT HEIGHT TO EXCEED BYPASS FRICTION
IF AIR COOLING UNIT IS LOCATED OVERHEAD THE SPRAY WATER PUMP & EQUALIZING LINE SHOULD BE OMITTED AND THE WARM WATER RETURNED BY GRAVITY TO THIS POINT.
A
TEMP. CONTROL VALVE
WARM WATER RETURN TO SPRAY HDR.
SPRAY NOZZLES
ICE BUNKER
THERMOMETERS
REFRIG. WATER SUPPLY TO AIR COOLING UNIT.
AIR COOLING UNIT
BYPASS WATER
FLOAT VALVE
TO SEWER
SPRAY CIRCULATING WATER PUMP
MANUALLY OPER. VALVES
AIR COOLER CIRC. WATER PUMP
OVERFLOW
WATER LEVEL
STRAINER
STRAINER
EQUALIZING LINE BETWEEN ICE BUNKER AND AIR COOLING UNIT

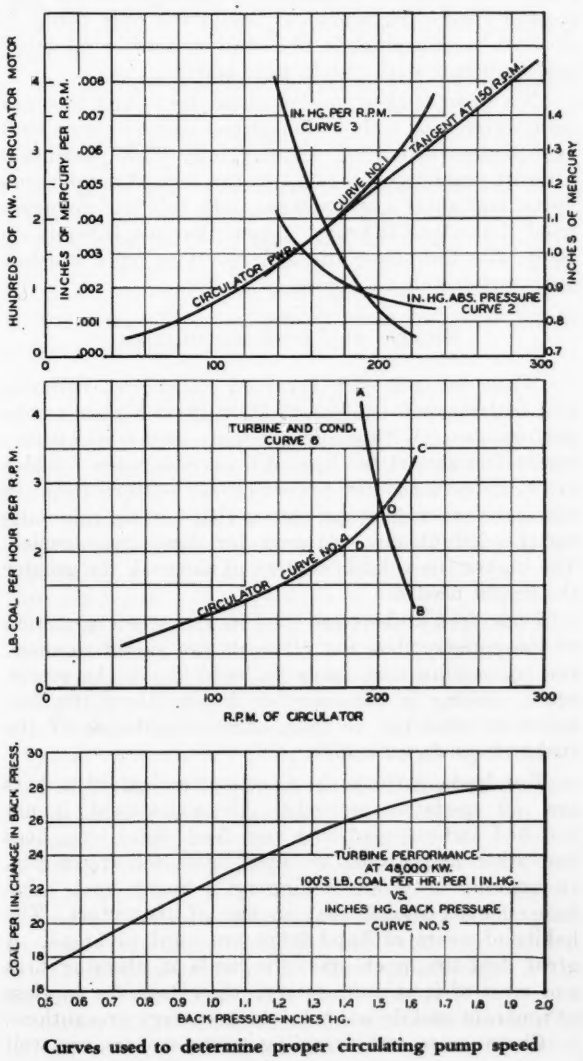
Fig. 2. Diagrammatic arrangement of piping for comfort cooling with ice

Optimum Circulating Pump Speed

By Richard Brown

WHEN an engineer wishes to determine the proper speed at which to run a circulating pump for a condenser, the usual method is to slow the pump down until the rate of vacuum loss appears to be excessive and then operate the pump at a slightly higher speed.

If it is desired to make an accurate determination of the optimum circulating pump's speed it is necessary to carry out very careful tests and to make a more or less complicated calculation. The following method appears to be quite simple and after some practice can be carried out quickly.


HUNDREDS OF KW. TO CIRCULATOR MOTOR
INCHES OF MERCURY PER R.P.M.
IN. HG. PER R.P.M. CURVE 3
TANGENT AT 150 R.P.M.
CURVE NO. 1
CIRCULATOR PWR.
IN. HG. ABS. PRESSURE CURVE 2
INCHES OF MERCURY
TURBINE AND COND. CURVE 6
CIRCULATOR CURVE NO. 4
LB. COAL PER HOUR PER R.P.M.
R.P.M. OF CIRCULATOR
COAL PER IN. CHANGE IN BACK PRESS.
TURBINE PERFORMANCE AT 48,000 KW. 100'S LB. COAL PER HR. PER 1 IN. HG. VS. INCHES HG. BACK PRESSURE CURVE NO. 5
BACK PRESSURE-INCHES HG.

Curves used to determine proper circulating pump speed

As the circulating pump is speeded up, the power required to drive it increases and the back pressure at the turbine exhaust decreases. When the rates of change of these effects expressed in pounds of coal are equal, the optimum speed is reached.

This point of optimum speed is shown at the intersection of curves 4 and 6 on the accompanying chart for one condition. If the pump is overspeeded coal will be lost in direct proportion to the area C.O.B. Also in the event of underspeeding coal will be lost in proportion to the area A.O.D.

In order to obtain the solution for any set of conditions it is necessary first to plot curves 1 and 2 from test data or calculation.

Curve 3 is the tangent of curve 2. The data for curve 3 are obtained by estimating tangents to curve 2 using a straight edge. With a little practice this can be done quickly. Curve 4 is the tangent of curve 1 multiplied by proper constants to express results in pounds of coal per r.p.m. For example: at 150 r.p.m. the tangent to curve 1 is approximately 35 kw. in 20 r.p.m. Assuming 0.9 lb. coal per kw-hr. the point on curve 4 would be $\frac{35}{20} \times 0.9 = 1.58$ lb. of coal per hr. per r.p.m.

Curve 5 is obtained preferably from manufacturer's data. In computing data for curve 5 one should take into consideration the change in hotwell temperature with changes in back pressure. This involves of course the effect on steam extraction in the case of an extraction turbine.

Curve 6 was plotted from the following tabulation:

R.P.M.	From Curve 3 Inches Hg per R.P.M.	From Curve 2 Back Pressure	From Curve 5 Coal per Inch Hg	For Curve 6 Column 2 × Column 4 = Coal per R.P.M.
180	.0027	.912	2160	5.84
190	.0019	.89	2140	4.07
200	.0013	.872	2120	2.76
210	.0010	.858	2105	2.105
220	.0006	.849	2095	1.257

The intersection of curves 4 and 6 at 0 gives the optimum speed of 202 r.p.m.

AT BELMONT in Switzerland a welded pipe arch is used for carrying the water supply to Lausanne over a stretch of marl and mud whose movement would wreck the pipe joints. Pipe is 19.7 in. diam., the span 137.8 ft. and rise 23 ft. Fixed reinforced concrete abutments anchor the ends, one being at about 7.5 ft. lower level than the other. Plates near the end and for stiffening ribs are 0.59 in. thick, at the center 0.47 in. thick, all being 39.37 in. long. Sections were built at the mill with lengths of 2 to 12 plates, then these sections set and lined on stagings and welded in place, after which the staging was removed. A temporary sleeve was used at joints near the center to aid alinement. Design is for working stress of 17,000 lb. per sq. in. in the metal, with pressure of 29.5 lb. per sq. in. in the pipe. Weight of the structure is 12 t., length of pipe in the arch 150.9 ft. An air valve at the top of the arch in the center permits removal of entrapped air.

Smoke Abatement Problems*

Furnace and Combustion Equipment Conditions that Present Difficulties to Smoke Inspector. By William G. Christy, Smoke Abatement Engineer, Hudson County, N. J.

IN MOST American communities, the greatest source of smoke is the hand firing of bituminous coal. This may occur in industrial and heating plants, locomotives, portable boilers and floating equipment.

With h.r.t. or straight tube water tube boilers, carrying a light or medium load with fairly good furnace height, the use of a very low volatile coal and careful firing, smoke can often be kept down to a point where there will be little if any violation of the average ordinance. This is usually unsatisfactory as we are still depending on the skill and care of the fireman as well as on the purchasing agent and the coal dealer to supply the same grade of coal.

Combustion Requires Time and Turbulence

If any of the conditions mentioned are not present, there is likely to be excessive smoke unless something is done to help out the fireman. In most hand fired plants, two essential elements of complete combustion are lacking—time and turbulence. Combustion space is insufficient, hence there is not enough time for proper combustion of the volatiles to take place. If the boilers are not too heavily overloaded, smoke can often be eliminated or greatly reduced by the installation of steam-air jets. This gives a lot of turbulence which helps to overcome the lack of proper furnace volume.

It is important to have the right kind of jets and to install them properly. Good results are obtained with a 2-in. induction tube and a ⅛-in. steam jet. The jet should be one diameter away from the end of the tube and kept on the exact central axis of the induction tube. Jets should be placed over the fire doors and pointed towards the bridge wall so as to strike it about 6 in. above the fuel bed. The jets should be placed from 10 in. to 15 in. apart, depending on the size of the boiler and the load. Steam connections should be run in such a manner with drips and traps so provided that comparatively dry steam is available. A quick opening valve, controlling all jets in one boiler ought to be used. Then they can be turned on immediately when needed.

Steam-air jets will do the job in many boilers if the load is not too heavy and the coal is not too high in volatile content. But they are more or less of a makeshift. Some plants equipped with jets continue to smoke. There is still too much dependence on the human element. It is necessary to use the jets every time coal is fired or the fuel bed is disturbed in any way. Some firemen object to using jets on account of the noise. Others, being careless or indifferent, just don't bother to turn them on. Any device which relies so much on the proper action of the plant operator seldom gives a good smoke performance.

Many plants have boilers set very low, that is, with furnace volumes which are much too small. If such boilers carry heavy loads, steam-air jets will not give a good smoke performance. About the only thing to do with such a plant is to install stokers or oil burners, or better still, put in new boilers.

We have spoken so far about h.r.t. and straight tube water tube boilers. Sometimes we run across bent tube boilers which are set very low. This presents a difficult problem on account of the limited combustion space and short gas passage. Jets will not do much good if the load is heavy. About the only thing to do is to raise the boiler, dig a deep pit or build a dutch oven and install oil burner or stoker.

Stokers as Smoke Eliminators

While we look with favor on stoker-fired furnaces and boilers, such equipment often gives a poor smoke performance. With many old underfeed installations, the boilers are set too low. Adequate furnace volumes are quite essential for proper stoker performance. In addition, experience has shown that certain minimum furnace heights are required for flame propagation. The higher the volatile content of the coal, the greater the height needed.

Underfeed stokers are used in almost every section of the country, but not all coals are suited to them. Gas, or coking coal tends to build up in the retort, often making it necessary to knock down the fuel bed with slice bar or rake. Any disturbance of the fuel bed produces smoke.

Hundreds, perhaps thousands, of underfeed stokers are not operated properly. Air adjustment is not watched and changed with coal feed. Slice bars, hoes and other firing tools are used much too frequently. In banking or when picking up a heavy load, some firemen even shovel coal on top of the retort. The habits of years of hand-firing are hard to break. A great deal too much smoke is made in cleaning fires and most of it is unnecessary. Operators are careless or ignorant and do not take the necessary precautions.

Chain grate and traveling grate stokers are well

*Abstracted from an address delivered at Annual Meeting of Smoke Prevention Association, Buffalo, N. Y., June 20, 1934.

suited for burning bituminous coal, especially the higher ash coals of the West. Many of the older natural draft chain grate installations pollute our atmosphere. Seldom do they violate the average ordinance, but they often emit No. 1 or No. 2 smoke for hours. Turbulence, supplied by introduction of overfire air at high velocity, will usually clear up the stack. The latest models of forced draft chain or traveling grate stokers, with zones for controlling air, give excellent results. Experience has shown that overfire air is needed with such installations. This is supplied by a small blower giving high static pressure, discharging into a row of nozzles through the ignition arch.

Pulverized coal installations sometimes make excessive smoke. On some of the older jobs, this may be due to insufficient furnace volume. In time, the mills get worn and the coal is too coarse, resulting in smoke violations. The trouble may be due to improper adjustment of air and coal feed. Another common source of trouble is starting up a cold boiler too quickly. Load demands should be anticipated as much as possible. Signal systems or telephones ought to be provided and boiler room operators notified in advance of increased demands for steam. Those using steam should be instructed to anticipate their requirements. Pulverized coal apparatus, like all mechanical equipment, needs proper inspection, service and maintenance at regular intervals.

Oil burners are also the cause of many headaches for the smoke inspector. This is especially true in heating plants. The tips carbon up in many types of burners. If they are not cleaned promptly, the burner gets out of adjustment with consequent dense smoke. Sometimes trouble is caused by the owner trying to use a heavier grade of oil than that for which the equipment is designed. Oil smoke is more objectionable than coal smoke, as it carries a greasy soot which sticks to anything it touches, leaving spots and often eating holes in fabrics.

Maintenance an Important Factor

Items, such as maintenance and starting up cold boilers, mentioned in connection with stoker and powdered coal jobs, also apply to oil burners. Service and maintenance of fuel burning equipment cannot be repeated too often or stressed too much. They are so frequently overlooked. Every item and part of fuel burning equipment should have periodic inspection. Cleaning, repair and replacement should be attended to immediately. This applies to fuel pumps, strainers, heaters, valves, blowers, burners, motors, engines, gears, tuyeres, dead and dump plates, coal and ash conveyors, grinding mills, control apparatus, refractories, boiler heating surfaces, breechings, stacks and instruments.

Brief mention might be made of some of the new developments in oil burning. Much heavier oils will be used as fuel in the future. Right now oil of 2 deg. to 4 deg. Beaumé is being successfully used in burners. Acid sludge has been burned for some time by oil refineries. With the increase in the price of oil, there may be some use of colloidal fuel. Another development which is only in the experimental stage is the mixing of water and oil at high pressure.

Every plant which burns a potentially smoky fuel should be equipped with smoke indicators. The stack is usually not visible from the boiler room and many engineers and firemen do not know when their stack is smoking. If they can observe conditions readily, the necessary corrective measure can be taken immediately. Even in a plant equipped with indicators, there is still dependence on the human element. If the fireman doesn't look at the smoke indicator, naturally it does no good. The best type of indicator is that which lights a red light and blows a Klaxon horn when any smoke is made. This calls immediate attention to the condition. Operators usually correct it immediately so as to silence the horn.

Most wood working plants have waste in the form of sawdust and shavings, which are usually burned in the boiler plant. Unless provision is made for burning it properly, smoke and fly-ash are the result. Wood being highly volatile, requires a large furnace volume. The proper way to provide this is by means of a dutch oven in front of boiler. This should be equipped with baffles and arches so that the volatiles may be thoroughly mixed with air. In addition there ought to be provision for overfire air. Another important requirement is to have the wood waste fed uniformly to the fire.

Many other waste products are used for fuel. They usually require a special study. I believe it is possible to burn anything smokelessly if the furnace is designed and operated properly.

Those of us engaged in smoke work need a better method of measuring fly-ash. A visual determination by the Ringelmann chart is quite unsatisfactory. We need a simple method of measuring fly-ash content and also a standard by which to measure it and define a violation.

Human Element Is Key to Smoke Problems

In our discussion of smoke problems, we often give most of our attention to equipment and to fuel. While conditions must be right in the furnace to get complete combustion, the plants giving best smoke performance are those where everyone concerned with operation of those plants is smoke minded. Every owner, executive, purchasing agent and operator of fuel burning equipment ought to be smoke conscious.

Some of the high spots of the Hudson County regulations may be of interest. Hand firing of bituminous coal is not approved. Heating installations are approved for hand firing anthracite coal or coke. Stokers, oil burners or powdered coal are required for all new power boilers. Definite boiler furnace heights for stokers are tabulated for various types and sizes of boilers.

For pulverized coal, heat liberation in refractory furnaces is limited to 20,000 B.t.u. per cu. ft. per hr. Some provision for collecting fly-ash is required. Maximum heat liberation in heating boilers burning oil is 25,000 B.t.u. and in power boilers with refractory furnaces is 30,000. Proper furnace design is most important for oil burning but this is difficult to specify in rules.

Smoke indicators, making it possible for the operator to observe smoke conditions at all times, are required for new boiler plants. Fixed ventilation, to assure air for combustion, is a requisite for all fuel burning plants.

Combustion Conditions in Chain Grate Stokers

Investigation of Fuel Bed and Grate Temperatures Made in England and Reported by J. I. Maughan, H. B. Spaulding and B. M. Thornton in Engineering of London Show That Green Coal Extends About 60 Per Cent of the Length of the Fire. Layer of Ashes ½ in. to 1 in. Thick Proves Effective for Cooling of Grates

PREHEATING the air supplied to boiler furnaces is nearly a century old, but the application of the air preheater to the power station boiler did not become common practice until the general adoption of the regenerative or feed-heating cycle placed a definite limitation on the amount of heat which could be extracted from the flue gases by an economizer.

While there are stokers working with higher temperatures, 350 deg. F. would appear to be the maximum air temperature advisable if excessive maintenance charges are to be avoided. In order to obviate the high maintenance charges experienced with some stokers using preheated air, many expedients have been tried. While these attempts to prevent the burning of the links and stoker parts have ameliorated the troubles, it must be admitted that an entirely satisfactory method of overcoming excessive maintenance charges have not yet been produced.

A development which has recently proceeded rapidly has been the adoption of coal cleaning equipment by collieries and it is well known that low ash coals cause traveling grates to deteriorate more quickly than when burning the dirtier or high ash coals. It is therefore apparent that fuel bed temperatures on traveling grate stokers have increased considerably in recent years, not only because of the increased air temperatures, but also because of the lower ash in the fuel itself, and it may safely be assumed that such increased fuel-bed temperatures affect the maintenance charges on stokers in an adverse direction.

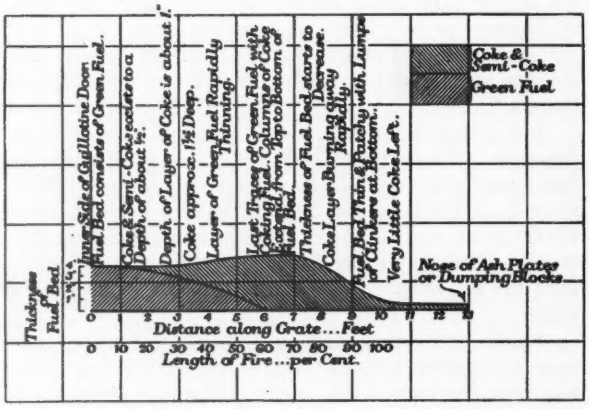

Thickness of Fuel Bed
Inner Side of Guillotine Door
Fuel Bed consists of Green Fuel.
Coke & Semi-Coke exudes to a Depth of about ½".
Depth of Layer of Coke is about 1".
Coke approx. 1½ Deep.
Layer of Green Fuel Rapidly Thinning.
Last Traces of Green Fuel with Coking Fuel. Columns of Coke & Coal from Top to Bottom of Fuel Bed.
Thickness of Fuel Bed starts to Decrease.
Coke Layer Burning away Rapidly.
Fuel Bed Thin & Patchy with Lumps of Clinkers at Bottom.
Very Little Coke Left.
Nose of Ash Plates or Dumping Blocks
Coke & Semi-Coke
Green Fuel
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Distance along Grate...Feet
0 10 20 30 40 50 60 70 80 90 100
Length of Fire...per Cent.

Fig. 1. Section through the fuel bed showing variation of green coal and coke

Higher maintenance charges caused by these two factors have presented a serious problem to stoker users. There is no doubt that in many cases the most economical proportions of boiler, economizer and air heater cannot be realized in practice, because of the limitations placed on the size of the air heater by the stoker.

Investigation Made by Removeable Grid

Quite recently the authors undertook an investigation on the mechanism of combustion on traveling grate stokers. A tray was erected in front of the stoker on which a grid 15 ft. long and 3 ft. wide with ½ in. square holes was placed. This grid was fed under the guillotine door so that it travelled at the same rate as the grate. When the grid reached the end of the grate, it was withdrawn bodily, the fire extinguished with a light water spray, and the fuel bed carefully examined. By repeating this procedure, it was possible to examine the conditions of the fuel bed, at any distance from the guillotine door and to observe the results of varying the fuel used.

For the purpose of describing a typical fuel bed as observed in these experiments, the total length of the fire, i.e., the distance from the inner face of the guillotine door to a position where the fuel was practically burned out, is termed 100 per cent. The fuel bed passing under the guillotine door was maintained throughout the tests at a constant thickness of 4 in. At 10 per cent of the length of the fire, the top layer of coal was converted to coke and semi-coke to a depth of about ½ in., leaving 3½ in. of green fuel below.

This layer of coke gradually thickened while the layer of green coal diminished in thickness as the examination progressed in the direction of the end of the grate, until, at an average of 60 per cent of the length of the fire, all traces of green coal had disappeared. With coking fuels, this point was reached 50 per cent of the length of the fire, while with free burning fuels it was reached at 70 per cent. The fuel bed coinciding with the disappearance of the coal in a green state consisted entirely of coke to a depth of some 4½ in. to 5 in., depending on the swelling properties of the coal. On progressing further towards the end of the fire, this coke layer showed signs of rapidly diminishing in thickness, until, at 100 per cent of the length of the fire, it was practically burned out, with the exception of a few isolated lumps of coke.

Perhaps the most important point to be observed from these experiments is that coal exists in a green state for such a comparatively high percentage of the length of the fire. This definitely shows the tapering layer of green fuel extending to a point 7 ft. from the inside of the guillotine door and supporting the layer of incandescent semi-coke which increases in thickness as ignition proceeds downwards through the

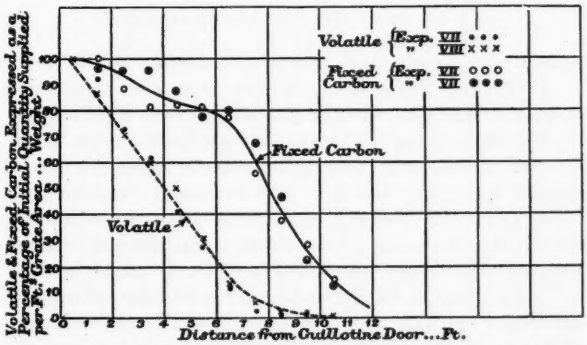

Volatile & Fixed Carbon Expressed as a Percentage of Initial Quantity Supplied per Ft. Grate Area ... Weight
Volatile {Exp. VII, VIII
Fixed Carbon {Exp. VII, VIII
Fixed Carbon
Volatile
Distance from Guillotine Door ... Ft.

Fig. 2. Variation of volatile and fixed carbon throughout length of fire

fuel bed. It is felt that this point has not been fully realized in the past, although in practice the presence of volatile, rising from the fuel bed at a position well towards the end of the fire, can be easily observed, a fact which indicates the presence of coal in a green or semi-green state. The above description of a typical fuel bed is shown diagrammatically in Fig. 1, in which the green coal and the coke are distinguished by different shading.

Green Coal Extends to About Half the Stoker Length

By sampling the fuel at numerous positions along the fuel bed and testing for volatile and fixed carbon content, results were obtained as shown in Fig. 2. In the first portion of the fuel bed, the volatile content of the residue on the grate falls rapidly, while the fixed carbon shows only a small decrease in quantity. When the majority of the volatiles are released, the quantity of fixed carbon rapidly diminishes. This would indicate that, while volatiles are still being released, the oxygen in the incoming air combines with the hydrocarbons in these volatiles, and there is little available for the combustion of the fixed carbon in the layer of coke and semi-coke lying above. On the other hand, when all the volatiles are freed, the whole of the supply of oxygen is available for the combustion of the fixed carbon.

From the above experiments it is clear that the first 60 per cent of the length of the fire in the grate must be relatively cool. For the balance of the fire the temperature of the links begins to rise until some point at which the heat loss by convection to the air passing between them is equal to the heat gained by contact with, and radiation from, the hot coke forming the fuel bed.

Various methods of reducing these temperatures were investigated. Increasing the burning rate per square foot causes a small reduction in temperature but this method was not as effective as had been expected. In addition the disadvantages of high forced draft for high rates of combustion made this method undesirable. Another method investigated was the recirculation of flue gas. By this method convection losses are increased and the grate temperature reduced owing to the increased velocity of air and flue gas through the links. A certain reduction in fuel bed temperature will also be noticed owing to the extra heat required to raise the temperature of the inert gases. The conclusion reached was that recirculation of gases cannot be considered a satisfactory way of controlling the temperture. The type of coal used has a considerable influence on these temperatures, in general the low rank coals giving lower temperatures, due probably to the larger quantity of air required. This is not considered satisfactory control, however, because considerations of price in any locality limit the choice of fuels that can be used economically.

The most satisfactory method of control was by artificially raising the ash content of the fuels. In practice this is done by adding an auxiliary hopper for the ash in such a way as to automatically give a ½ in. to 1 in. layer between the stoker and the green coal. Tests with various fuels showed temperature reductions of from 250 to 300 deg. F., the maximum temperature being reached on the part of the stoker following the end of the front arch.

Economic Steam Generation in Great Britain

The "Analyses and Summaries of the Returns of Fuel Consumption and Units Generated" for the year ended December 31, 1933, have recently been issued by the British Electricity Commission. Returns were received from 489 generating stations, a decrease of 32 from last year, the difference being mainly due to the closing of 43 small stations. The plants concerned generated 14,964 million kw-hr., an increase of 9.6 per cent over 1932, for a fuel consumption of 10.7 million tons, an increase of 4.95 per cent.

The 270 steam-operated stations produced 96.04 per cent of the total. In the remaining stations water power was responsible (53 stations) for 2.2 per cent, waste heat or gas for 0.82 per cent, oil engines for 0.51 per cent, and gas producers, refuse, and town's gas for 0.42 per cent. The average coal consumption of the steam-operated stations was 1.65 lb. per kw-hr. generated as against 1.74 lb. in 1932; the figures ranged from an average of 1.4 lb. at those producing over 200 million kw-hr., increasing with diminishing outputs to 7.4 lb. at stations with an output of less than 50,000 kw-hr.

The premier position both in fuel consumption and thermal efficiency on the year's working was taken by Clarence Dock (Liverpool) with 1.12 lb. and 26.06 per cent, which generated 276 million kw-hr. at a load factor of 56.8 per cent. Portishead (Bristol) with 21.59 per cent lowered its fuel consumption from the 1.15 lb. with which it secured first place last year to 1.13 lb.

Twenty-five oil-engine stations attained thermal efficiencies above the Clarence Dock figure. The station at Yeovil came first with 30.64, and Buxton second with 29.89. The best gas producer station was Leek with 12.61 per cent, but Bridgwater used least fuel per kw-hr.—1.92 lb.

Automatic Equipment in a SMALL BOILER PLANT

AN INTERESTING installation of automatic boiler room equipment is found in the Iron Fireman Manufacturing Company's plant at Cleveland, Ohio. Coal is dumped from the railroad car directly onto a screw conveyor which in combination with a vertical elevator automatically transfers the coal from the car to a storage bunker at the rate of approximately 15 tons per hour. This unloading and elevating equipment is driven by a 5 hp. electric motor.

The coal bunker or silo has a capacity of 90 tons and is constructed of vitrified circular tile—is 13 ft. inside diameter and approximately 25 ft. high. The cone shaped base of the silo discharges by gravity into the hopper of the standard Iron Fireman underfeed stoker set under the boiler as shown by Fig. 2.

This unit, Model 5 CL, differs from the customary stoker of this type in that the hopper instead of being placed close to the boiler front is set back 20 feet from the boiler. The worm conveyor and air supply duct are merely extended leaving the principal elements of drive and coal delivery into the combustion chamber essentially the same as the more common short model stoker. The length of this extension is made to suit the coal storage facilities of the particular plants in which the installations are made. Usually the existing coal bin can be used by constructing in it a bottom having sloping sides.

The boiler is a 180 hp. firebox type and electrical controls operate the stoker automatically to maintain constant steam pressure. The only manual attention required in operating the entire equipment is that of removing the ash and this takes only a few minutes twice each day.

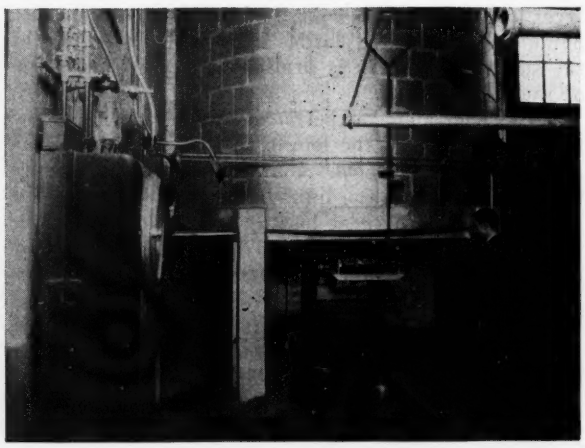
Fig. 1 (center). Exterior view, showing coal silo and coal conveyor used to transfer coal from car to silo

Fig. 2 (left, below). Worm conveyor and air supply duct carrying coal from hopper underneath silo to combustion chamber

Fig. 3 (right, below). Another view of the conveyor shown in Fig. 2 but looking toward the hopper. Coal from silo is delivered directly to hopper

Smaller Plants Can Install Automatic Control to Advantage

Automatic, efficient equipment previously found in large power stations is now proving very popular in these smaller plants due to the tremendous savings that can be made in operating costs. Complete equipment of this kind will frequently pay for itself in less than two years' time—many installations have paid out in less than one year.



Putting a BOILER *on the Line*

Rules to Guide the Operators of Pulverized Fuel and Stoker Fired Units

PROPER OPERATING methods for the boiler and turbine rooms should be developed primarily to avoid accidents to operators and other workmen and to protect the equipment. For this reason the chief engineer should formulate a definite schedule to be followed when the equipment is put in or taken out of service. The following outline can be used as a basis for such a schedule, blank spaces should be filled in by the chief engineer so as to apply to the individual units. These rules were formulated by an operating code committee of the old N. E. L. A. and were intended to be general so as to cover all types and sizes of plants.

Stoker Fired

1. Remove all danger or Out of Service signs placed on valves and equipment controls and inspect all boiler setting doors to see that they are tightly closed.
2. See that blow-off valves are all closed. Where a safety stop gate valve is connected to the blow-off line see that this valve is open.
3. Open all vent valves.
4. Close all drain valves.
5. See that valves controlling water column and pressure gages are in operating condition and open.
6. See that water column blow down valves are closed.
7. Open the waterfeed valves to the boilers slowly for one or two turns. On boilers equipped with separate economizers see that the valves between the boilers and economizers and economizer vents are open.
8. Fill the boiler to about.....
9. Operate superheater drains according to instructions of boiler engineer.
10. Start the stoker and fill the grate about..... way down with coal. This requires about.....revolutions of the stoker.
11. See that the change-over valve on the water back lines is set for raw water.
12. Open the feed and discharge valves on the water backs.
13. See that tell tales are open and discharging water, and that the drains are clear.
14. Open the stack damper to give about.....in. draft in the furnace.
15. Dig holes in the coal over the tuyeres and put a shovelful of fire in each hole or use wood and oil-soaked waste.
16. Cover the fire with green coal and start the stoker slowly.
17. When the fire is hot enough to insure proper coking, start both the induced and forced draft fans slowly. The electrician should inspect motor-driven fans before starting.
18. Adjust the stack damper to.....in. draft over the fire.
19. Apply.....in. blast on the forced draft.
20. Close all vents on the boiler as soon as total elimination of gas and air from boiler is insured.
21. Note that the pressure gage is operating.
22. Turn on the spray of the clinker crusher pit as soon as hot ash begins to accumulate.
23. Raise.....lb. pressure on the boiler and unlock the automatic non-return valve.
24. At.....lb. pressure, drain feedwater regulator if it is of the thermostatic type.
25. Increase the speed of the fans, for both induced and forced draft, to such a degree as may be required.
26. Bring the boiler gage pressure gradually up to .....lb.
27. See that the drain valves between the main and automatic non-return valves are open.
28. Open the main stop valve by-pass valve and blow out all water from the line between the automatic non-return valve and the main stop valve.
29. Close the drain valves.
30. Open the trap line valve above the automatic non-return valve.
31. Open the main stop valve and close the bypass on the same.
32. Increase the stoker speed and air blast until the boiler begins to steam. Keep the fire as light as possible. The rate of increasing the blast and stoker speed is determined by how fast the boiler must be put on the line.
33. Set the change-over valve on the water back line for condensate.
34. Blow down water columns to check the water level and test safety valves when boiler is on line.
35. Cut in automatic boiler feed control.

Pulverized Fuel

1. Proceed according to Rules 1-9 (inclusive) for stokers.
2. Have coal in pulverized coal bunkers or for unit systems have coal in the green coal bunkers and the pulverizing mill ready for operation.
3. See that stack damper is open.
4. Start the induced draft fan slowly.
5. Start the primary air fans and adjust speed to give.....in. pressure.
6. Adjust the secondary air door opening and the induced draft fan speed to give.....in. furnace draft.
7. Light.....burners. The following procedure in lighting burners is suggested: Open the dampers (gates) above the coal feeder; light the torch and insert it in the burner; close the main switch on the feeder motor; open the primary air damper on the feeder; start the feeder motor by operating the push-button control; throw the feeder motor clutch.
8. Close all vents on the boiler as soon as total elimination of gas and air from the boiler is insured.
9. Note that the pressure gage is operating.
10. Add burners according to the individual plant schedule. The rate at which burners are to be added is determined by the time allowed for putting the

boiler on the line, giving due consideration to the extent of the furnace repairs which may have been made while the boiler was down.

11. Proceed according to Stoker Rules 23-31 inclusive, until the boiler is on the line and then according to Stoker Rules 33-34 and 35.

TAKING A BOILER OFF THE LINE

1. Cut off the coal supply.
2. Set the change over valve on the water back line for raw water.
3. Run the coal feed pipes and hopper empty.
4. Cut off the fuel feed.
5. Shut off feedwater valves, keeping the water in sight above the nut on the gage glass.
6. (Stoker-fired only.) After the coal in the furnace is burned out cut off all forced draft.
7. (Pulverized fuel-fired only.) Shut off primary air fan.
8. (Stoker-fired only.) Shut off the spray line in clinker crush pit.
9. Stop both the induced and forced draft fans.
10. As the steam pressure drops, shut the main stop valve.
11. Close the trap line valve above the automatic non-return valve.
12. Lock the automatic non-return valve.
13. Open the vent valves on the superheater and open the drain valves between the main stop and automatic non-return valves.
14. Close the stack damper.
15. Shut off the water-back feed and discharge valves after the water-back soot chamber has been cleaned.
16. Empty the boiler through the blow-off valves when the setting has cooled. The superheater drain valves on other boilers must be closed while this is being done.
17. When the boiler is empty see that the safety stop valve in the blow-off line is closed and then close all blow-off or guard valves and cocks.
18. Hang danger or Out of Service signs on the main stop, main feed, blow-off valves and control board.

Chain Grate Stokers In Germany

Ultimate Development Proves That Ignition Arches Are Superfluous with This Type of Stoker

GERMAN DEVELOPMENTS on traveling grate stokers during the past 30 yr. were reviewed by Freiedrich Schulte, Essen, Germany, before the last Carnegie Institute Conference on Bituminous coal. The chain grate stoker was introduced in Germany about 1901. About 10 yr. later the traveling grate stoker was developed. In this type of stoker the chain serves only for propelling and supporting the grate bars which may be changed while in operation.

Shortly after this a swinging back wall was introduced, preventing excessive drafts of cold air over the back of the stoker and giving more complete utilization of fuel. This resulted in an increased capacity of about 20 per cent. Forced draft was introduced about 1914 with another 20 per cent increase in capacity. No development occurred during the war, but after the war the stoker was divided into sections, making it possible to regulate the air quantity in accordance with combustion requirements throughout the length of the grate.

The ignition arch was still retained, the length ranging from 45 to 55 per cent of the length of the grate. Later it was found that a short distance of about two feet between the ignition arch and the grate could be considerably increased without retarding ignition. Following American example and German research, fire boxes of 8 to 12 ft. and even higher were constructed for traveling grate stokers.

Chance led in 1926 to the knowledge that ignition arches in case of traveling grate stokers were superfluous. Up to that time it was believed that a traveling grate had to have an ignition arch due to the absence of the fire below. That this is not true was shown when pulverized coal was introduced as a supplementary fuel. In case of the latter the ignition arch has to be omitted for constructive reasons; the pulverized coal used as a supplementary fuel was expected to replace it as the source of ignition.

It was now found in practice that even without the pulverized coal flame, the fuel on the grate ignited dependably, and that by omission of the ignition arch the efficiency of the grate could even be considerably increased. It was recognized that the ignition arch as the source of ignition could be replaced by radiation from the flame and gases, the study of gaseous radiation having progressed considerably in the meanwhile. It was shown that the ignition arch had actually reduced the capacity of the first part of the grate.

With this, the development of the traveling grate stoker in Germany practically ended. Thenceforth on the basis of the knowledge acquired, the work of perfecting the grate technically was carried on continuously, and in a few years an increase of capacity of 1200 to 1300 lb. per sq. ft. was effected. In official tests as much as 1500 lb. per sq. ft. was recorded, in comparison with a capacity in 1910 of about 400 lb. per sq. ft. Thus in a period of time of 27 yr. the capacity had been quadrupled.

Air Conditioning for Hotel Statler

RECENTLY the Statler Hotel at Detroit installed a Westinghouse air-conditioning system. Rooms have individual units which may be controlled by the occupant. Cold water is supplied by a central 167 t. vacuum cooling system, located in the basement. In some of the air-conditioned rooms, the cooling units, which also humidify, are concealed under a grilled ledge beneath the windows. In other rooms, the units are located along the walls. Each of the room units is rated at 0.5 t. These individual room units will circulate 225 c.f.m. of air, using a motor rated at 1/125 hp. and provide an ample supply of fresh, comfortable air drawn from the outside.

Readers' Conference

Heating System Difficulties

After reading the description of Heating System Difficulties as outlined on page 324 of the July issue of Power Plant Engineering, it occurs to me that the difficulties are not corrected and it is also remarkable that the system as originally installed ever worked with any measure of satisfaction.

The reason for the difficulties were very simple if one will give thought to the reason why steam circulates in any piping system.

The fundamental principles which must be kept in mind are that steam cannot flow from one point to another unless a difference in pressure exists between the point of supply and the point to which the steam is desired to flow.

When a group of pipe coils or radiators are connected to a common source of steam supply, at some reasonably constant pressure and when this same set of pipe coils or radiators are connected at their outlet ends into one common return line which is piped or connected into one steam trap, one is almost certain to run into the difficulty of some radiators being heated and some refusing to heat.

Several explanations may be made depending upon the viewpoint of the person who makes the explanation as to just why this unequal steam distribution occurs. But the fact remains, nevertheless, that the unsatisfactory condition always develops when several radiators are connected into only one trap.

The heating system as described in the July issue can be made to work perfectly if each of the pipe coils is fitted with a steam trap on the outlet from each of the coils. The cast-iron radiators that have been connected in series so as to form one radiator should also be fitted with a steam trap on the extreme end of the group. The traps therefore would in each case control the condensate leaving each radiator and the discharge from all the steam traps will be connected in the return line as at present installed. This return line should empty into a return type steam trap and in the filling process would be vented to the atmosphere. As soon as the return trap would become filled to the dumping position steam pressure would be admitted to the trap forcing the condensation out of the trap into the heater or receptacle such as is required in their particular case. When empty, the return trap would be in the filling position again, in which case it would be vented to the atmosphere, allowing any condensate in the heating system to flow freely into the trap.

In a condition such as outlined herewith it should be apparent that a certain steam supply pressure is maintained on the supply lines to all radiators and that because a steam trap is installed on the outlet of each radiator no steam can escape from the radiators. Thus a certain constant pressure is maintained in all radiators up to the steam traps and as soon as condensate accumulates in the trap, this condensate is released by the trap into the return line and since this return line is connected into a trap that is vented to the atmosphere, it is very clear that less pressure exists in the return line than exists in the radiators.

This condition therefore establishes and maintains a definite lower pressure condition at the outlet end of all the radiators than is maintained in the supply of steam to the inlet end of the radiators. There is, therefore, nothing to prevent the flow of the steam into and through each and every radiator in the system.

Any arrangement of check valves or any other manually operated device employed in an attempt to control condensate from a group of radiators, using only one steam trap as a common unit to all radiators, always gives trouble and therefore it is not at all good practice.

Hartford, Conn. Harry W. Benton.

Helpful Kinks

In the Readers' Conference department for August I was interested in the contributions of Mr. Kennedy and Mr. Schaphorst. When drilling holes where it is impossible to erect a post or where a post is not available we use a long narrow board with a short rope and an iron hook at one end. There is never a plan so awkward that a purchase can not be obtained for the hook. The ratchet or electric drill is then set up under the board and the operator sits astride it putting on the requisite pressure to drill the hole.

As for the device for heating rivets, nothing is so satisfactory as a plate with a number of holes into which the rivets are inserted, the heads preventing their dropping through. This method allows the rivet to be heated to its best temperature while having the head cooler and prevents burning.

While Mr. Schaphorst has an excellent method for screwing small fittings he could improve upon it by using, for large diameters, a turn or so of rope sling with a pipe inserted in the longer loop and the end bearing on the pipe to be moved. This gives a tighter purchase when more strain is put on the hook and works most satisfactorily.

Passaic, N. J. Mark Bell.

Remaking Joints on Steel Cylinder Rectifiers

These Rectifiers must operate under a high vacuum and if this is to be maintained all joints must be perfect, as the slightest leakage will destroy the high vacuum. When these rectifiers have to be opened up, they should first be allowed to cool down, and the electrical and water pipe connections broken, and any water drained off. The vacuum should then be broken, the mercury should be carefully collected, and if necessary filtered. The jointing rings should then be care-

fully removed from their grooves and closely examined. The slightest hair crack is sufficient to cause leakage and let down the vacuum.

Any rings found to be defective should be discarded. Where rings are found to be defective the groove should be closely examined to see that roughness in the grooves has not caused the defect. The grooves should be cleaned with a piece of hardwood of the same shape as the groove, they should then be polished bright with emery cloth, any dust being then removed by a blower and a soft cloth. The cathode plate should be washed first with benzol and then with methylated spirits. The rest of the casting should be polished bright with emery cloth.

The ring under the mercury diffuser should be examined, also the inside edges of the lower portion of the diffuser for minute blobs and splashes of mercury. These must be cleaned off. New joint rings should be fitted where necessary. These also should be washed with benzol and methylated spirits before fitting in position. The joints can then be remade and the rectifier reassembled. Two essentials for this class of overhaul are care and cleanliness, as a minute scratch or piece of dirt will be sufficient to cause loss of vacuum and failure.

Herts, England. W. E. WARNER.

Emergency Pipe Wrench

I NOTE on page 386 of the August issue an item by W. F. Schaphorst in reference to an engineer's useful pipe wrench. In my opinion it is useless as an iron pipe wrench. A wrench using this principle has been made and has been used by plumbers for years. To tighten or loosen brass pipe, nickel plated or not, for black or galvanized iron pipe for either high pressure water or steam, the wrench will be practically useless for either tightening up a new pipe or for loosening up an old iron pipe joint. Instead of a leather or other soft strap, a piece of strong chain may be used in an emergency for working with iron pipe, but no makeshift wrench can replace the steel tooth iron pipe wrench if iron pipe is to be worked upon. Of course a wrench made upon the principle described by Mr. Schaphorst is all right for brass pipe in an emergency.

Toronto, Ont. JAMES E. NOBLE.

Making a Flexible Power Transmission for Buffing and Drilling

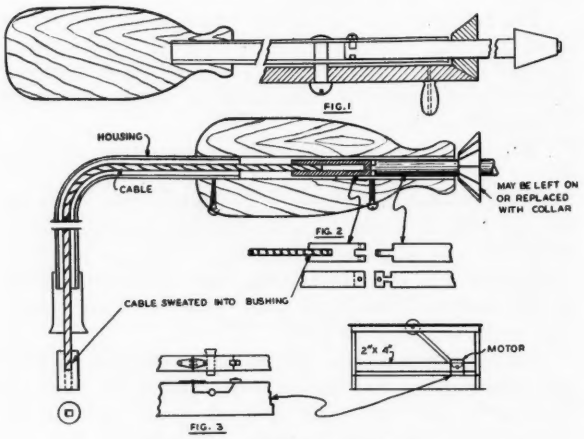
HAVING OCCASION to use a flexible shaft polishing and drilling equipment quite frequently but being unable to purchase one, I recently constructed one out of odds and ends picked up around our shop. An old hand or breast drill such as can be purchased for about 50 cents is about all one needs. Usually such drills consist of a shaft carrying the chuck held in a tube by means of a rivet or set screw shown in Fig. 1.

Remove the set screw which releases the shaft and remove the large gear which drives the pinion on the chuck shaft. Remove the handle, being careful not to break it since we will use it again.

Saw off the tube which serves as a bearing for the chuck shaft so that it extends a half inch beyond the end of the shaft. Obtain an old speedometer cable housing and drill the handle on its closed end to fit this cable housing.

Obtain a brass bushing of diameter equal to the chuck shaft. Enlarge the hole in the bushing if necessary to fit tightly whatever is to serve as the flexible driveshaft. In this connection, 3x16 in. stranded wire clothesline or guy wire may be used but the author, after quite a bit of experimenting, finally found an old auto exhaust heater control cable to be the best bet. It was wound in the correct direction (counter clockwise) and has stood up under heavy loads.

Sweat the bushing onto the cable after cutting the end of the shaft and bushing as shown in Fig. 2. A small hole through both bushing and shaft holds the two together and the pin cannot drop out to release



Details of flexible transmission

the coupling since it revolves inside the tube when the assembly is completed.

Insert the cable in its housing and sweat another bushing on the other end allowing one inch of slack in the cable. That is, when the housing and cable are laid flat the cable (measured from bushing to bushing) should be 1 to 1½-in. longer than the housing.

The bushing on the motor end may have either a female thread or may be squared out inside to fit a pin driven into a hole in the motor shaft. To drill out the motor shaft simply start the motor and hold the correct size drill against the end of its revolving shaft.

The writer used a two by four to support the motor end of the flexible housing, drilling a hole the correct size and then cutting through the hole as shown to form a hinged block held in place by a turnbuckle to allow the device to be disengaged from the motor when not in use.

The flexible shaft housing is slightly smaller than the chuck shaft tube so to assemble shove the wooden handle on the housing far enough to allow the coupling to be made and the pin inserted. Now bring the handle back into place and insert a machine screw through the handle into the tapped hole in the chuck shaft tube. This serves to hold the chuck tube in place as well as to hold the chuck shaft in the tube (due to the groove in the shaft). A wood screw through the other end of the handle holds the flexible shaft housing, although this is hardly necessary since the housing

cannot come out of the handle due to its being retained by the bushing on the motor end.

I have used this flexible power transmission for drilling as large as 3/16 in. holes in wood with success but care should be used not to force the work too fast. Too much emphasis cannot be placed on the importance of selecting a good flexible drive shaft. Readers may think of other substitutes but they must be wound counter clockwise so that when the twisting motion is applied they will not tend to unwind or buckle. If the cable to be used is wound in the wrong direction it will be necessary to reverse the twist before attempting to use it with any success.

Sparta, Wisconsin. VERNON W. PALEN.

Inexpensive Hydro Plant Betterments

RECENT EXAMINATIONS of a number of hydroelectric plants suggest that not a few improvements to facilitate operation can be made at moderate cost in many such stations. In this branch of power production it is easy to carry on the service year after year without looking at the design from a critical standpoint. Stream flow cycles come and go; loads are handled effectively with respect to available water and other generating facilities if present; and maintenance requirements are intelligently met. Sometimes the visit of an outside engineer points the way toward improvements which will not require a meeting of a board of directors for authorization, but which nevertheless will make operation easier and smoother. Familiarity with local conditions tends toward their acceptance unless downright hazardous or inefficient.

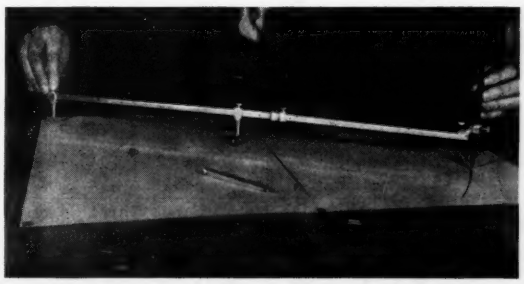
Haphazard illumination prevails in too many otherwise well-run plants. Below the operating room floor bare lamps are still too often found to light shafts, couplings, lower bearings, governors, wheel pits and power pumps. Modern fixtures can often be substitued at the identical lamp sockets to achieve an amazing improvement in conditions. Energy for station use, while an appreciable part of the total output in these days, is too cheap to warrant subnormal illumination during periods when concentrated light is needed on particular equipment assemblies. Again, modern wiring supplies permit extremely flexible arrangement of relocated outlets and switching. The controlled use of floodlighting in the darker corners of hydro plants offer many possibilities. Here even piecemeal development may be effective, showing the engineer's superiors in the company set-up the benefits of modernization on a small scale and pointing the way toward more comprehensive improvements.

Ventilation and drainage conditions frequently leave much to be desired behind the scenes in hydro stations. Dry basements are not beyond attainment in many cases, with a little study of moisture accumulation plus a modest appropriation for equipment. Space heaters of the electric type offer useful service in many places where dampness is undesirable, and few apparatus units are more flexible. Incoming energy is generally available for operating such units when the plant is shut down in utility practice. and in industrial power plants storage battery equipment is widely available for circuit-breaker, emergency exciter, lighting and other service which may well include heating in specified areas. Finally, accessibility deserves more consideration in many plants. It should not cost an excessive sum to provide a semi-stairway in place of a vertical ladder to reach a mezzanine platform carrying a bus structure and disconnecting switches. The relocation of such switches may be achieved in many cases at relatively low cost in proportion to the benefits, provided the plant interior is not congested. Water-proof interior telephone equipment, wider hatchways, more accessible crane facilities——these are but a few of the betterments which deserve investigation in the interest of more convenient operation.

Cambridge, Mass. H. S. KNOWLTON.

New Beam Compass

IN THIS NEW beam compass, a special device is provided for holding the user's favorite ruling pen, pencil, crayons or brushes. A micrometer adjustment with a smooth, positive action includes an adjustment for



This beam compass rides on a wheel

tilting the pen at various angles and a wheel attachment makes possible the movement of the entire compass rapidly from one part of a drawing to another.

Kansas City, Mo. ALLEN P. CHILD.

Oilsoaked Belting

WHILE THERE ARE VARIOUS liquids which can be used for degreasing belting that has become oilsoaked, the most effective remedy for this condition is prevention, and it is a fact that there is usually little excuse for allowing a belt to become soaked with oil. When conditions are examined, in practically every case it will be found that the cause is due either to an antiquated pulley with a common oil hole drilled into the hub, the belt running on a loose pulley part of the time, or to an adjacent bearing of equally ancient type that will not retain its oil. Such crude provisions for oiling a loose pulley as a simple hole drilled through the hub should never be tolerated in this day and age. Keep the oil in the pulley and in the bearing, and you will not have it in the belt. Oil caps and other oil-retaining devices are too readily available and too easily applied to allow this double waste. For the waste is double. The oil itself is wasted to begin with, and then time is wasted getting it out of the belt.

Once in the belt in any large amount, it will be necessary to remove it, because an oilsoaked belt slips easily, slipping on the pulley generates heat, heat thins

the oil in the belt and makes it slip still more, and so on indefinitely. If the belt is not in service over the week end and on Sunday, coil it up and give it a good soaking by submerging it in naphtha for about 8 or 10 hr., allow it to dry, after uncoiling for double that length of time or more, wipe the face of it carefully with waste, replace it on the pulleys, and lubricate it sparingly on the back with neatsfoot oil. A certain amount of such oil is necessary in a belt to lubricate the continually flexing fibers properly.

Peoria, Ill. JOHN E. HYLER.

Tubular Boilers

CALCULATING the horsepower rating of a horizontal return tubular boiler is not a difficult problem but it does take considerable time and the task becomes irksome when it becomes necessary to make many of these calculations in order to make a selection of a boiler with suitable dimensions and capacity. As my plant design work frequently calls for the solution of these problems I made up the accompanying table of dimensions and capacities which has saved many hours of time. The table is based on a rating of 10 sq. ft. of heating surface per boiler horsepower and, while it is not complete, by interpolation the ratings of those boilers not exactly tabulated may be estimated with sufficient accuracy for practical purposes.

Table showing various sizes of boilers with number and size of tubes with approximate boiler horsepower rating of each. Based on 10 sq. ft. of heating surface per boiler horsepower

Size of Boiler Diam. in.	Length ft.	Tubes No.	Size in.	B.HP.	Size of Boiler Diam. in.	Length ft.	Tubes No.	Size in.	B.HP.
54	14	54	3	71	72	14	110	3	155
		44	3½	66			126	3	173
		36	4	64			96	3½	156
							72	4	136
54	16	54	3	81	72	16	110	3	175
		44	3½	76			126	3	195
		36	4	75			96	3½	175
							72	4	153
60	14	72	3	98	72	20	110	3	195
		76	3	95			126	3	217
		54	3½	80			96	3½	195
		44	4	77			72	4	170
60	16	72	3	105	78	18	136	3	214
		76	3	108			148	3	228
		54	3½	92			118	3½	213
		44	4	86			88	4	187
60	18	72	3	118	78	20	136	3	236
		76	3	122			148	3	253
		54	3½	103			118	3½	237
		44	4	99			88	4	208
66	16	88	3	126	84	18	162	3	252
		102	3	142			180	3	274
		72	3½	120			142	3½	254
		54	4	106			108	4	225
66	18	88	3	142	84	20	162	3	280
		102	3	160			180	3	305
		72	3½	134			142	3½	282
		54	4	120			108	4	250

Homemade Pipe Insulation

ENGINEERS have very likely noticed that some of the newspapers are running so-called "technical" articles.

This writer's belief is that newspapers should leave such matters to the technical journals because in practically every item which I have seen to date, the writer of the newspaper article has gone rather far.

For example, I have before me an article entitled, "Homemade Pipe Insulation" in which the reader of the newspaper is told that sweating of cold pipes can be averted by the use of "shirt boards." Somebody living on Long Island describes a method of insulating pipes to retain the heat in hot water and also to prevent the sweating of cold water pipes. Let me give you two paragraphs:

"The material used for insulation is the cardboard stiffeners sent by the laundry inside of newly washed shirts. These may come either with four straight sides or with one end cut out to fit the neckband. This irregularly shaped end should be cut off square. The sheets of cardboard are wrapped as tightly as possible around the pipes and may be neatly secured with wire, tape or glue.

"Previously I had tried strips of roofing paper and canvas—neither of which worked—both sweating as much as the bare pipe—besides, it is much easier to apply the cardboard, less expensive and without bulk."

Perhaps laundry cardboards are all right for hot pipes but this writer has very grave doubts concerning the practicability of such cardboard for cold pipes. They would soon become wet and would disintegrate.

For cold piping there is nothing better than first class cork insulation and it is generally worth while to have an expert install the covering. Don't try to do it yourself, unless you really know something about it.

Newark, N. J. W. F. SCHAPHORST.

Care of Laminated Switches

THE CONTACTS AND laminated brushes should be examined at regular and frequent intervals for signs of burning and pitting. Inspection should always be made after any fault opening. Contacts found to be badly fitted should be replaced, if not too bad they may be trimmed up. Trimming up may be done by a small fine file, taking care that the fixed and moving contacts bear properly together after any trimming. The sparking contacts must also be kept in perfect condition for if these get worn more work will be thrown on the main contacts. Laminated brushes should bear with their whole surface on the fixed contact. The efficiency of the contact may be tested by covering the fixed contact with tin foil and then closing the switch. If the brush has been bearing perfectly the paper will be marked with a number of thin parallel marks, if not the paper will be cut through where the contact is too hard or missed altogether where contact is not made at all. They should be trimmed until the contact is perfect. Any irregularities can be trimmed off using a fine file and in between the contacts cleaned with a stiff wire brush the wires of which are at least half an inch long. In time dirt and grit will collect between the laminations and if allowed to remain will permanently alter the set of the brush.

Herts, England. W. E. WARNER.

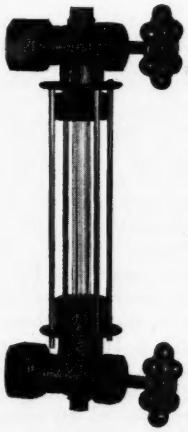
THAT STOKERS are economical in small plants is indicated by the fact that of 200,000 stokers in use in the United States, reported as of Jan. 1, 1934, 120,000 were of 225 hp. or less capacity. Some 40,000 for bituminous and 35,000 for anthracite were reported in the household field.

New Equipment

Improved Lunkenheimer Automatic Liquid Gage

THE LUNKENHEIMER Co., Cincinnati, O., has made a distinctive change in their Automatic Liquid Gage known as Fig. 1183. All internal working parts—stem, gland, retaining ring, stuffing box washers and ball checks—are now made of stainless steel, to provide maximum resistance to corrosion and eliminate sticking. The new pressure rating is 350 lb. G.L.P. (Gas-Liquid) at 450 deg. F.

The new Fig. 1183, here illustrated, is designed for use on pressure tanks, gravity tanks and other reservoirs handling liquids which attack brass or bronze—where a non-corrodible, non-sticking gage is essential.



Dependability and safety are insured by the exceptionally sturdy construction; automatic closure of ball checks in both upper and lower valves in the event of glass breakage; non-corrodible and non-sticking working parts; easy and safe replacement of new glasses; cone shape packings which prevent leakage around glass, and minimize glass breakage due to over-packing and torsional strains; reduced fire and accident hazard; standard pipe plug in lower valve body for drain connection. The gage is Parkerized—a protective coating that retards rust and improves appearance.

Ideal Heavy-Duty Portable Blower

RECENTLY ADDED to the Ideal line of Portable Cleaners manufactured by the Ideal Commutator Dresser Co., Sycamore, Ill., is the new 1934 Jumbo model portable electric machine. Designed for the most extreme heavy-duty dust, dirt and lint cleaning work. It has three distinct uses; it blows, suctions and sprays.

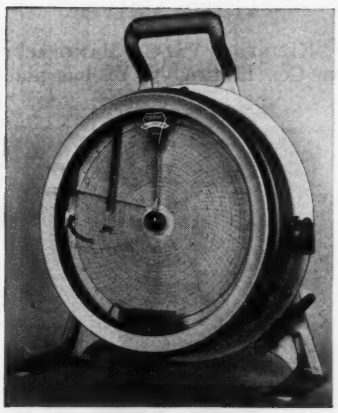
The Jumbo is powered by a 1 hp. General Electric motor. It has a water column lift of 46.25 in.—a fan diameter of 2½ in.

Its blast of clean, dry air blows or vacuums all the dirt from motors, machinery, nooks, corners, upholstery, etc. It cleans irregular surfaces before painting. The sprayer attachment sprays paint, varnish, duco, oil, insecticides, or in fact any liquid or powder. It has dozens of uses in the plant, warehouse, mill or office.

Foxboro Portable Thermometer

WITH CONVENIENCE and accuracy as the dominating features, the Foxboro Co., Foxboro, Mass., has developed a new portable recording thermometer that is light in weight, hangs vertical when picked up by the handle, and stands firmly without tipping when the door is open. Sliding wedges make the interior quickly accessible and the ink bottle and dropper are in an accessible but well protected location. The pen used is gold-plated and V-shaped.

This portable instrument is furnished with either self-contained



or long-distance type thermometers in 8 or 10-in. case sizes, that shown here being the 10-in. size with a range of —25 to +125 deg. A companion instrument with identically the same features may be had for recording pressures. These instruments can be removed from their stands by unscrewing three bolts and can then be fastened to a wall or board for permanent use, if so desired.

New Liquid Belt Dressing

AFTER CONDUCTING A series of tests by which samples of 10-ply rubber belting were immersed in various liquids for 28 days at room temperature, The B. F. Goodrich Co., Akron, O., developed a solution which is said to be excellent for dressing rubber belts.

For several years, castor oil was an accepted dressing for rubber belts. Certain leather belt dressings were used on rubber with inefficient and usually harmful results. But the very thing that made oil effective on leather, its ability to lubricate the entire thickness of leather, often rendered ruinous results on rubber belting.

The new Goodrich Liquid Belt Dressing merely softens the rubber surface and does not penetrate and deteriorate the body of the belt. Safe and easy to apply, it increases pulley grip and horsepower delivery of belts for a longer time after application than ever attained before.

A New General Electric Thruster

A NUMBER OF IMPROVEMENTS in the G-E Thrustor, a self-contained combination of motor-driven centrifugal pump, oil chamber, and piston that produces a smooth straight-line thrust through a definite length of stroke especially suitable for the operation of clutches, brakes, valves, doors, etc., have been announced by the General Electric Co., Schenectady, N. Y.

The new line of Thrustors consists of a complete range of standard models providing 10 combinations of thrust and stroke ratings varying from 50 to 3200 lb. thrust and from 2 to 16 in. stroke.

In the new Thrustor, the impeller housing of the centrifugal pump is stationary, a rigid shaft running in ball bearings connecting the impeller to the driving motor. A number of driving motor

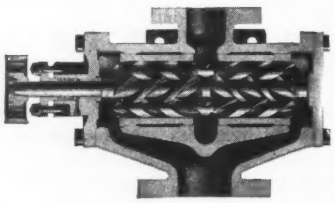
arrangements are available—ac. or dc. All motors are totally enclosed (except dc. and single-phase motors on the 50-pound size) for protection against dirt and moisture. For single-phase service, capacitor motors are used on all Thrustors rated 100 lb. and greater thrust. For 25-cycle service, a special step-up gear train is provided to obtain the same impeller speed as that produced in 60-cycle service. For 50-cycle supply, impellers of slightly greater diameter are used to maintain rated thrust capacity.

Interchangeable base plates are available for clevis or rigid mounting of the device. Tilting as much as 45 deg. away from the vertical is permissible with the new Thrustors. It is also designed for continuous operation with the piston in the stalled position.

As a smooth acting, straight-line operating device, subject to manual, remote, or fully automatic control, the Thrustor is suitable for a wide variety of applications in many fields.

Portable Rotary Pumping Unit

HIGH-SPEED, ROTARY displacement pump developed by the De Laval Steam Turbine Co., Trenton, N. J., is known as the De Laval-IMO pump. Driven at approximately 1675 r.p.m. by a 60-hp. gasoline engine, it delivers 90 gal. per min. against 495 lb. per sq. in. pressure with a suction lift equivalent to 14 in. of mercury. The



pump has only three working parts, a central power rotor and two sealing rotors, which mesh in such manner that the liquid is carried through, as by a continuously acting piston, without shock or pulsation. There are no timing gears or separate bearings, and but one stuffing box, which is subjected to suction pressure only. Pump and engine may be mounted on a trailer for convenient portability.

World's Largest Lamp

IN THE accompanying illustration is shown a laboratory model of a 100,000 watt incandescent lamp bulb displayed by the Westinghouse Lamp Company at A Century of Progress, Chicago. This

lamp, if lighted, would operate at perhaps half the temperature of the sun's atmosphere, searing everything that came close to it.

The glass bulb has walls which are ¼ in. thick to resist a crushing strain of 40,000 lb. induced by the necessary vacuum. Its tungsten filaments are as thick as a fountain pen.

New Kennedy Bronze Gate Valve

KENNEDY VALVE MANUFACTURING Co., Elmira, N. Y., has placed on the market a new heavy standard bronze gate valve designed for 150 lb. working steam pressure and 250 lb. working water, oil or gas pressure.

One of the outstanding features of this new valve, which is known as Fig. 23, is a large bonnet hex which is placed close to the body to make the entire valve more rigid and also to assist easier removal of the bonnet and stem assembly when the valve is installed with close clearances.

Another important feature is the design of the stem which is made of specially tough bronze, has an unusually large number of heavy contact threads, and has a flexible connection between the stem head and the disc.

Additional features are a deep stuffing box with specially selected high graphite molded packing rings, bronze gland and heavy packing nut, the substantial non-heating non-slipping handwheel, and the heavy pipe end hexes. These valves are built in a complete range of sizes up to 3 in.

Handy Test Pliers

FOR PULLING fuses, and testing open circuits, blown fuses, base receptacles and grounded fixtures, the test pliers illustrated herewith should prove a useful tool in the kit of any engineer or electrician. It is manufactured and marketed by the Star Fuse Co., New York City. It is made of bakelite and fiber and incorporates in its construction a small carbon lamp in series with a 1600 ohm resistance which gives positive indication when the test terminals on the pliers are placed in contact with a "live" circuit. It is rated for use on 110 and 250 v. circuits but the lamp will light on 65 volts. The lamp itself is thoroughly protected from mechanical injury and has a life of 1000 hr.

RECENTLY DEVELOPED as a patching material for concrete is Stonhard Stontite, to be applied in liquid form to the free or open side of a floor or structure, even while under hydrostatic pressure. It is stated to be suitable for a range from large leaks to seepage by the manufacturers, Stonhard Co., Philadelphia, Pa.

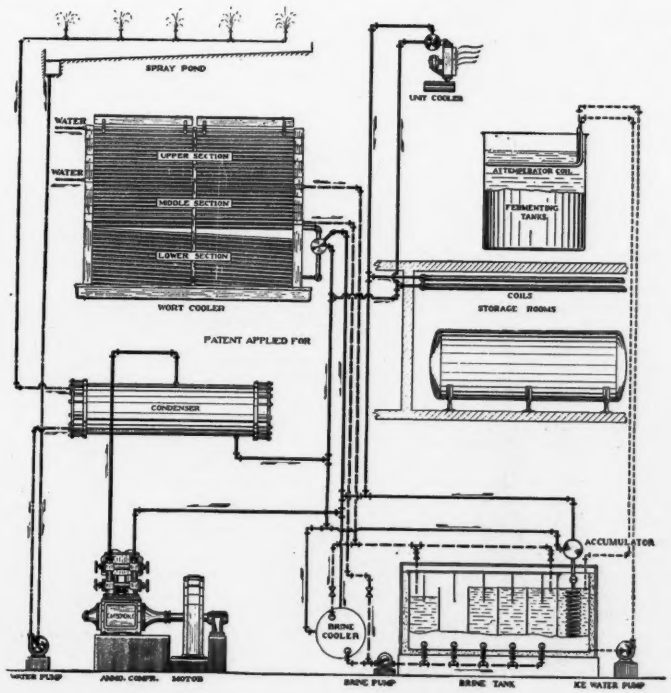
Carbondale Wort Cooling System

CARBONDALE MACHINE CO., Carbondale, Pa., has recently developed a new Wort Cooling System, illustrated by the accompanying diagram.

This drawing shows the general piping hook-up of the entire system—the water into and out of the upper section or first stage; the brine circulation through the middle section or second stage; and the ammonia circulation, with modern float control, through the lower section or third stage. All tubes of the third stage, excepting the top tube, are slanted, and communicate directly with vertical manifolds or headers. This construction induces rapid circulation of the ammonia and maximum cooling effect.

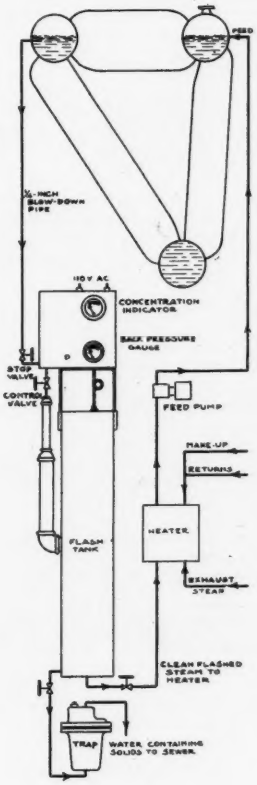
Water used in the upper section of the 3-stage wort cooler may be taken from the spray pond supply shown directly over the wort cooler, provided a suitable supply of well or other cool water is not available; also when the cost of existing water supply is prohibitive.

The diagram also makes clear the many possible adaptations of this Carbondale system—the use of liquid ammonia for unit coolers where such coolers are employed—liquid ammonia to pipe coils in storage rooms—liquid ammonia for cooling the brine in the brine tank—and ice water for the attemperator coils in the fermenting tanks.



Continuous Blow-Down System

FRANKLIN POWER SPECIALTY CO., Cleveland, Ohio, recently introduced a continuous blow-down system for controlling boiler water solids with a minimum heat and water loss. The system consists of a control valve which regulates the quantity of blow-down; a concentration indicator for reading the value of the concentration at any moment; special design of flash tanks for heat and water recovery and a trap for discharging the discarded water. Two sizes are available, Model 01 for blow-down of less than 1500 lb. per hr. and model 02 for blow-down of between 1500 and 3000 lb. per hr.



Henry Banning Bradford

HENRY BANNING BRADFORD, for many years Vice-President of the Edge Moor Iron Co., died July 25, at his summer home, Middle Neck, on the Bohemia River, Cecil County, Md., after an illness of several months.

After his graduation from Yale, Mr. Bradford became associated with the Baltimore and Ohio Railroad Co., with which he was connected from 1881 to 1889. He then became mechanical engineer for the Diamond State Engineering Co. and left that company to become Vice-President of the Edge Moor Iron Co., which position he held until his retirement in 1932.

Mr. Bradford's more than forty years' active participation in the boiler industry in this country has brought to him associations and friendships which are spread widely throughout the United States.

During the years of his association with William F. Sellers, former President of the Edge Moor Iron Co., he gave much to the design of the Edge Moor box header boilers and in later years to water tube boilers and other products of his company.

Accidental Motor Starting Prevented

POSITIVE PREVENTION of accidental starting, which permits automatic starting and taking full advantage of the motor's capacity without danger of burning it out, is announced by The Lincoln Electric Co. It is impossible to close the starting current unintentionally as the red stop button extends around and beyond the green start button, so that a bump or fall against the control would move only the stop button. Once the motor is stopped, the only way it can be restarted is by pressing the recessed start button with the fingertip.

Full advantage of the motor's capacity is permitted by an inverse time limit protection which allows carrying a small overload a long

time or a heavy load a short time, immediate motor starting upon resumption of current being insured by low voltage release with two wire control.

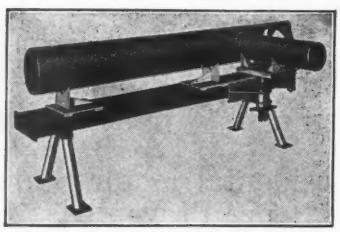
Three types are furnished for different horsepowers, 3 to 30 hp., and voltages from 110 to 550.

Mechanical moving parts are cadmium plated, relay armature has cushion action, surface creepage between lines is eliminated by an asbestos compound barrier, and considerable room is saved by having the switch drop down instead of swing to the side.

Wiring of more than one control station is permitted by the arrangement of the starter case and overload can be reset on the outside of the case, while the case is locked.

Oster-Williams Pipe Welding Bench

OSTER-WILLIAMS of Cleveland has just announced a new pipe welding assembly bench which is capable of handling all sizes of pipe up to 12 in. in diameter and will line up accurately and hold in position for tacking, fittings, flanges and branches at any angle. For handling longer lengths an extension bench can be supplied. The extension can be moved to any



angle to the main bench. Adjustable elevator, which can be used at any position on the main bench or on the extension, controls the vertical alinement of the work. Accurate angle alinement is obtained by setting elevator to desired angle. Elevator supports are graduated to make setting easy.

Elevating and vee supports are all steel. The main bench weighs 700 lb. and the extension 300 lb. The bench can be disassembled for portability and re-assembled quickly and easily. The dimensions of the main bench I-beam are 8 ft. long by 1 ft. wide and the extension 6 ft. long by 1 ft. wide. Their height is 2 ft.

News From the Field

U. S. RUBBER PRODUCTS, INC., New York City, has announced the appointment of H. S. McPherson as Manager of Mechanical Sales in the St. Louis District. Mr. McPherson, who has been with the company for over 15 yr., was formerly in charge of mechanical sales in the Boston district. W. G. Mueller, for more than 25 yr. a salesman with the company, largely in the Connecticut territory, has been promoted to Manager of Mechanical Sales, Boston Branch of U. S. Rubber Products, Inc.

FOR POWER TRANSMISSION, code authority members have been approved as follows: Subdivision of the Machinery and Allied Products Industry—Charles E. Brinley, Philadelphia, Pa.; E. M. Carver, Mishawaka, Ind.; H. P. Dey, Cuyahoga Falls, Ohio; W. H. Fisher, Chambersburg, Pa.; L. B. Hall, Muncy, Pa.; D. E. Lewellen, Columbus, Ind.; C. Walter Ostrand, Chicago, Ill.; Walter Siegerist, St. Louis, Mo. E. G. Vail, administration member, to serve during the pleasure of the Administrator.

THE BORDEN CO., Warren, Ohio, announces the appointment of Rodney E. Matthews as District Manager of the Southern territory. For some years Mr. Matthews has been connected with a well known supply house in New Orleans and is widely acquainted in the South.

LINK-BELT CO., Chicago, Ill., announces the appointment of J. J. Richards as Manager of Link-Belt Co.'s Vibrating Screen Department, succeeding Harry L Strube, who has been promoted to the position of Assistant Chief Engineer of the company's Philadelphia plants. Mr. Richards will continue to make his headquarters in Philadelphia.

THE MERRIAM CO., Cleveland, Ohio, is planning an increase in its manufacturing space. The new building is needed for gas and oil engine rebuilding; thus permitting the entire present space to be used for the welding division and for the manufacture of flow and pressure instruments.

ALLIS-CHALMERS MFG. CO., Milwaukee, announces the removal of its Chicago District Office to the new Field Building, 135 South LaSalle Street. B. F. Bilsland is Manager of the Chicago District.

KENNETH WILLIAMS, a graduate of the University of Michigan in 1923, has been appointed manager of sales for the department of engineering and construction of Byllesby, Eng. & Mgt. Corp., according to H. W. Fuller, vice president in charge of that department. The engineering department of the Byllesby corporation, which has for some years practically confined its services to the subsidiaries of Standard Gas & Elec. Co., is expanding its activities to include general engineering practice for independent clients.

ANNOUNCEMENT has just been made that Henry Kreisinger, New York City, has been appointed chairman of the Smoke Prevention Committee by the American Boiler Manufacturers Association and affiliated industries. This association includes not only the boiler manufacturers but also mechanical stokers and other burning equipment manufacturers. As chairman, Mr. Kreisinger will coöperate with the Smoke Prevention Association and work with it on the solution of its problems.

EFFECTIVE SEPTEMBER 1, 1934, the Eagle-Picher Sales Company, 100 per cent owned subsidiary of the Eagle-Picher Lead Company, will take over the sales and distribution of products manufactured by the Eagle-Picher Lead Company. The Eagle-Picher Sales Company will have the same sales personnel as that formerly employed by the Eagle-Picher Lead Company, thereby assuring continuation of Eagle-Picher service.

R. X. RAYMOND, who has been associated with the Chain Belt Co. of Milwaukee, Wis., for over 14 yr., has been appointed manager of the Minneapolis district. He will succeed G. A. Gunther, who is being transferred to become district manager of the Detroit territory. Mr. Raymond goes to Minneapolis from the Chicago office. Both of these men have had previous experience in both the manufacturing and engineering departments at the factory, and their knowledge of the application of chains and conveyors makes them exceedingly capable to handle the problems of the respective fields to which they have been sent.

TUBE-TURNS of Louisville, Ky., announces removal of its New York City office from 30 Church St. to 110 E. 42nd St. W. P. Curley will continue in charge as district manager, assisted by I. A. Pfeil.

CONTRACT has been let recently for a new addition to the plant of Refractory & Engineering Corp., Port Kennedy, Pa., to accommodate demands for their refractory cements and insulations.

IN THE six-year suit of Bernitz Furnace Appliance Co. of Boston against D. B. Wilson Co. of Philadelphia for alleged wrongful use of the Bernitz process of silicon carbide air-cooled furnace walls, decision was recently given by Judge W. H. Kirkpatrick in the Federal Court in favor of the defendant.

ANNOUNCEMENT is made by the Chain Belt Co., Milwaukee, Wis., that Rapp & Hollins, Inc., 7001 North Clark St., Chicago, will represent the company in Northern Indiana, Northern Illinois, Eastern Iowa and Southern Wisconsin.

THE POOLE FOUNDRY & MACHINE CO., Woodberry, Baltimore, Md., announces the acquisition of all domestic and foreign patents of the Poole, all metal, gear, lubricated type flexible coupling. These patents were formerly owned by the Poole Engineering & Machine Co.

L. D. WYANT of 800 South Main Street, Tulsa, Okla., has been appointed Oklahoma State representative for Kieley and Mueller, Inc., of New York City.

CHICAGO PNEUMATIC TOOL Company announces the change of address of its Birmingham, Ala., office from its former location, 1829-31 South Second Ave. to 211 South 20th St. This change was effected August 31st and provides increased facilities for both sales and service activities. W. S. Lynch is Manager of the Birmingham District Office.

HENRY M. CHASE, recently retired from the engineering staff of the Worthington Pump & Machinery Corp. after over 40 yr. of service. He entered the employ of the Holyoke Works of the corporation, then the Deane Steam Pump Co., as a detail draftsman. He was particularly active in the early days of direct-acting compound and triple expansion engines and invented and patented a number of improvements. Mr. Chase is a native of Holyoke, Mass., and graduated from Massachusetts Institute of Technology in the class of 1891.

AS THE RESULT of the activities of a special sub-committee the S.A.E.-A.S.M.E. Diesel Fuel Research Committee has published a report which is available to those interested for 50 cents a copy. This report gives a survey of the present fuel oil market, a history of the past efforts toward standardization of builders' specifications, a discussion of the ignition characteristics, with descriptions of the various crucible and bomb methods, engine test methods, special testing engines and a detailed history of the researches conducted on ignition characteristics. Copies may be obtained from the headquarters of the A.S.M.E., 29 W. 39th St., New York City, or from the Diesel Engine Manufacturers Association, 2 W. 45th St., New York City.

L. S. STEPHENS has been elected to succeed D. B. Piersen as president of the Stephens-Adamson Mfg. Co. of Aurora, Ill. Mr. Piersen, one of the founders of the firm in 1901, was made chairman of the board upon the resignation of W. W. Stephens of Pasadena, Calif. L. S. Stephens, the new president, has been active in the firm since 1914. In 1921 he was made superintendent and in 1926 vice president in charge of production. There are no other changes in the firm.

TWO LARGE ADJUSTABLE orifices have recently been purchased from Bailey Meter Co. by the U. S. Navy for use in testing aircraft carburetors under actual flying conditions. One of these orifices will be installed in a 16-in. line and the other in an 8-in. line carrying air to carburetors on test. This air will vary in temperature from —60 deg. to +200 deg. F. In the case of the 16-in. size, the gate segment may be set to accommodate a maximum capacity of 450 lb. per min. of 200-deg. air as well as a minimum capacity of 20 lb. per min. of —60-deg. air.

ANNOUNCEMENT IS MADE of the return of the Carborundum programs to the air for the season of 1934-35. These programs are scheduled for Saturday nights 10:00 to 10:30 E.S.T. beginning October 20th, over a coast to coast network of Columbia Broadcasting System stations.

BAILEY METER CO., Cleveland, Ohio, announces that its Canadian subsidiary, Bailey Meter Co., Ltd., has received an order for 21 recording and integrating steam flow meters with auxiliary pressure recorders for installation in the Imperial Oil Refineries Ltd., plant at Sarnia, Ontario, to measure steam and to record steam pressure to various departments.

FOR THE ELECTRICAL MANUFACTURING INDUSTRY the following have been approved as code authority members: Wylie Brown, New York, N. Y.; A. D. Byler, Chicago, Ill.; Clarence L. Collens, Cleveland, Ohio; J. R. Cook, Hartford, Conn.; H. B. Crouse, Syracuse, N. Y.; R. Edwards, New York, N. Y.; Otto H. Falk, Milwaukee, Wis.; F. R. Fishback, Cleveland, Ohio; R. H. Goodwillie, Yonkers, N. Y.; F. C. Hodkinson, New York, N. Y.; F. C. Jones, New York, N. Y.; B. W. Kerr, Greensburg, Pa.; A. L. Lindemann, Milwaukee, Wis.; F. W. Magin, Milwaukee, Wis.; Geo. W. Mason, Detroit, Mich.; F. A. Merrick, East Pittsburgh, Pa.; S. L. Nicholson, New York, N. Y.; C. L. Pierce, Jr., Pittsburgh, Pa.; D. G. Phelps, Hartford, Conn.; P. B. Postlethwaite, St. Louis, Mo.; Walter Robbins, New York, N. Y.; R. J. Russell, St. Louis, Mo.; E. O. Shreve, Schenectady, N. Y.; W. E. Sprackling, New York, N. Y.; Chas. H. Strawbridge, Chicago, Ill.; Gerard Swope, New York, N. Y.; J. S. Tritle, East Pittsburgh, Pa.; J. R. Trumbull, Plainville, Conn.; H. S. Walker, Conshohocken, Pa.; J. F. Wright, Newark, Del.

ON SEPTEMBER 1ST Crane Co. announced the transfer of P. R. Mork from New York to the general office in Chicago where he will serve as Vice-President in Charge of Sales. Mr. Mork, who was Vice-President in Charge of the New

York territory, enjoys a wide acquaintance throughout the industry having served as Manager of the Minneapolis and Duluth branches before going to New York in 1927. In his new position he will assume the duties of Vice-President H. W. Seymour, who is on leave of absence due to ill health. P. R. Berryman, formerly Vice-President of the Trenton Potteries, has succeeded Mr. Mork as Manager of the New York branch and associate branches of Crane Co. in the metropolitan area.

JOHN HUNTER, of St. Louis, Missouri, has recently taken a position with the Riley Stoker Corporation, Worcester, Massachusetts, as Advisory Engineer. He will devote all of his time to the affairs of the Riley Stoker Corp. Mr. Hunter is well known in engineering circles, having been connected with marine engineering and power plant construction and operation for a great many years. He has been active in the affairs of the American Society of Mechanical Engineers, having acted as Manager and Vice President and having served on a number of important engineering committees of that Society. He is also a member of the Uniform Boiler Law Society.

ORDERS reported received during August by Combustion Engineering Co., Inc., of New York, include the largest 1400-lb. pressure steam generating unit ever built, which will go into the Rouge Plant of the Ford Motor Co.; two large boiler units for the Detroit Edison Co.; two complete steam generating units for the U. S. Industrial Alcohol Co.; sixty-four welded drums for Naval boilers; two fifty-ton chemical and waste-heat recovery units for a Virginia pulp mill; two steam generators for a public utility in Nanking, China; five water-cooled furnaces for DuPont; four boilers for a Texas sulphur company; and other units for a hospital, a flour mill and a PWA project.

M. S. PALMER, for many years Mid-Western District Sales Manager of Consolidated Ashcroft Hancock Co., Inc., with headquarters at Chicago, has been made Sales Manager of the Hancock Valve Division of that company, and will be located at the general sales headquarters in Bridgeport, Conn. C. L. Harris, formerly in charge of the Pittsburgh office of the company, has been made Mid-Western District Sales Manager of the company with headquarters in Chicago. W. F. Loos, formerly sales representative in Dallas, Texas, has been made District Sales Manager with headquarters at Pittsburgh.

For the Engineer's Library

A NEW VACUUM-TUBE VOLTMETER which has a response proportional to the logarithm of the input voltage is described in Bulletin No. 111 published by the Harvard Engineering School, Harvard University, Cambridge, Mass. The bulletin prepared by Frederick V. Hunt shows the necessary vacuum-tube circuits using commercially available tubes. Price 25 cents.

SUBHARMONIC FREQUENCIES produced in Non-Linear Systems, by W. M. Goodhue, is the title of Bulletin 112 published by the Harvard Engineering School, Harvard University, Cambridge, Mass. Price 25 cents. If a current or voltage wave containing no component whatsoever of fundamental frequency, but only the higher harmonics, operates through a non-linear device, a fundamental component may be produced. This phenomena was investigated by the author after the galvanometer readings had been found in error as much as 7 per cent due to this phenomenon.

DETERMINATION of the Direction and Velocity of Flow of Fluids, by Lionel S. Marks, is the title of Bulletin 113 published by Harvard Engineering School, Harvard University, Cambridge, Mass. Price 25 cents. This is an exhaustive treatise on the use of the pitot tube showing the application of the tube, modifications of the tube to give more consistent readings, the effect of alternation and other factors upon the performance of the tube.

PRINCIPLES OF ENGINEERING THERMODYNAMICS. By Newton C. Ebaugh. Published by Foote & Davies Co., Atlanta, Ga. Size 8½ by 11 in., flexible paper cover, planographed. 164 pp. Price $2.25.

An elementary text book of thermodynamics, arranged so as to be of maxi-

mum value to those interested in the fundamentals of the science upon which present day power plant process and equipment are based. Engineering thermodynamics is a science built upon relatively few cardinal principles, each step of which should be thoroughly understood before proceeding with the application of the basic principles to practice.

The arrangement of the book is based on this fact and the organization of the first eight chapters is such as to lay the foundation for many different applications in the field of engineering. The remaining chapters deal with the application of these principles to practice; steam cycles, combustion engine cycles, gas compression and refrigeration.

Thermodynamics cannot very well be treated without mathematics and upon first glance mathematics seem to predominate throughout the book. Closer examination, however, shows that these are simple developments of fundamental formulas or the working out of examples. In a planographed book of this kind, a reproduction of a typewritten page, mathematics occupies more space and stands out more prominently than in a printed book.

MUNICIPAL ELECTRIC PLANT MANAGERS by Edna C. Macmahon, 42-page, paper bound monograph, published 1934, by Public Administration Service, Chicago, price 60 cents.

Having for its purpose the presentation of facts about the whole group of municipal electric plants, this monograph deals with the mode of selection, the background, training and experience, the salary and tenure of managers of this class of plants in such a way as to make possible helpful comparisons and contrasts. The data presented are the result of a questionnaire to which 36 per cent of the active municipal plants responded.

BULLETIN 100-B12, illustrating and describing the Harrison Inert Gas Producer, has just been issued by Roots-Connersville Blower Corp. of Connersville, Ind., who are sole licensees under the Harrison patent issued Jan. 17, 1933. These units are built to produce inert gas containing less than 1 per cent oxygen and zero per cent carbon monoxide when operating on manufactured or natural gas, or fuel oil.

Air and gas are delivered separately to a water-cooled combustion chamber where the gas burns, forming the inert gas, which is discharged through a cooler to bring its temperature down to a useable point. The drive unit can be either a gas or gasoline engine, or an electric motor. Illustrations of the various types already supplied are shown in the bulletin.

THE DESIGN AND USE OF INSTRUMENTS AND ACCURATE MECHANISM by T. N. Whitehead, 283 pages, illustrated, 1934, The MacMillan Co., New York. Price $3.50.

Designers of instruments and those who use instruments for extremely accurate determinations will find in this book highly technical discussions which will aid in eliminating and correcting for errors in precision instrument readings. The author has drawn on his experience with instruments to analyze the actual physical causes of inaccuracy and has considered these in relation to practical problems of design and use. The introductory chapter is on instruments and their parts, followed by five chapters on the theory of errors, the remaining six chapters deal specifically with technical phases of instrument design including the planning of instruments and the human factor involved in their use. The author is assistant professor in the Harvard Graduate School of Business Administration.

FIVE PLACE TABLE OF NATURAL TRIGONOMETRIC FUNCTIONS to Hundredths of a Degree. Compiled by Amelia De Lella. Size 8 by 10 in. Paper cover, 50 pages. Published by John Wiley and Sons, Inc. New York, 1934. Price $1.00.

This table according to the author was compiled in response to a frequently expressed desire on the part of engineers for a five place table of natural trigonometric functions of angles expressed in degrees and hundredths of a degree. Over 300 years ago Henry Briggs, Professor of Geometry at Oxford calculated a table of sines and tangents for every hundredth of a degree from 0 to 90 deg. The sines were carried to 15 places and the tangents to 10. After his death his colleague Henry Gellibrand, Professor of Astronomy at Gresham College, London, completed Briggs' work and published it as part of his "Trigonometric Brittanica." In addition to the table of natural trigonometric functions, the log sines and log tangents were also calculated by Briggs for every hundredth of a degree.

Through the courtesy of Roger Howsen, Librarian of Columbia University, Miss De Lella obtained the use of a copy of Gellibrand's work and thereby was enabled to compile this table. The table gives sines, cosines, tangents and cotangents for each hundredth of a degree from 0 to 90, to five places. Miss De Lella is in the Central Station Engineering Department of the General Electric Co. at Schenectady, N. Y.

FIVE BULLETINS have recently been issued by the Engineering Experiment Station of the University of Illinois, Urbana, Ill. For a limited time copies of these bulletins may be obtained free of charge by those interested. These bulletins include the following:

Circular 22, Condensation of Moisture in Flues, by William R. Morgan, reports tests conducted in a standard three story dwelling with a warm air heating plant. No condensation occurred with anthracite, because the temperature of the flue gas was never below the dew point. With bituminous coal a maximum condensation of about 0.38 lb. per hr. occurred with a firing rate of 20,000 B.t.u. per hr. With manufactured gas maximum condensation of about 6.75 lb. per hr. occurs with a firing rate of 84,000 B.t.u. per hr. Comparable data for oil and natural gas are not available.

Circular 23, Repeated-Stress Testing Machines Used in the Materials Testing Laboratory of the University of Illinois, by Herbert F. Moore and Glen N. Krouse describes a number of the special testing machines used in the study of metals under repeated stress in the laboratories of the University over a period of 15 yr.

Bulletin 266, Investigation of Warm-Air Furnaces and Heating Systems, Part VI, by Alonzo P. Kratz and Seichi Konzo, is the ninth publication of a series and deals chiefly with tests of forced-air heating systems employing fans. Operating under different arrangements of automatic control it was found that a close regulation of house and room temperature within desired limits can be obtained with wide variation of outside temperatures.

Bulletin 267, An Investigation of Reinforced Concrete Columns, by Frank E. Richart and Rex L. Brown, deals with the tests of concrete columns performed at the University of Illinois and includes a discussion of effects as revealed by the tests. End conditions, rate and manner of loading, size of columns, protective shells, spiral reinforcement, bond stresses in vertical reinforcement and vertical reinforcement of high strength are discussed.

Bulletin 268, The Mechanical Aeration of Sewage by Harold E. Babbitt, describes a series of tests on sewage taken from the main Champaign outflow sewer, mostly ordinary domestic sewers free from industrial wastes. Results of investigations showed that with a sewage of this type, a satisfactory activated sludge could be formed at a moderate period of aeration and a moderate power consumption using Sheffield Paddles and an Aspirator.

ROLLER-SMITH COMPANY, New York City, announces a new line of instrument and control switches as illustrated and described in the company's Catalog No. 9. These new switches, designated, Type "R Rotary," are used extensively on switchboards and control panels of all kinds. The instrument switches are used in connection with electrical measuring instruments and the control switches are used for establishing proper connections to air and oil circuit breakers and other equipment of that nature.

Special attention is called to the fact that this new line has been worked out so as to provide a switch for every known requirement. These switches are very sturdy and compact and are as nearly fool-proof as it is possible to make apparatus of this kind.

SANFORD C. SMITH REFRACTORIES, INC., Buffalo, N. Y., under the title "Flame Brand" High Temperature Refractories, has issued a catalog describing the products manufactured by this company and giving specific data on baffling of boilers as well as to the engineering data pertaining to the subject.

THE HAYS CORP., Michigan City, Ind., has issued a new catalog describing Hays combustion recorders, gas analyzers, draft gages and boiler panels. Many new features have been incorporated in the designs of these instruments and the catalog is comprehensive in its description of this apparatus.

NEW LITERATURE released by the Worthington-Gamon Meter Co., Harrison, N. J., is as follows: M-975-B12, Watch Dog Disc Meter — Frost-proof Model with Open Gear Train; M-975-B13, Watch Dog Disc Meter—Frost-proof Model with enclosed gear train; M-975-B14, Watch Dog Disc Meter—Split Case Model with open gear train; M-975-B15, Watch Dog Disc Meter—Split Case Model with enclosed gear train; and, M-975-B16, Model R. Disc Meter.

WORTHINGTON PUMP & MACHINERY CORP., Harrison, N. J., has issued the following literature covering Worthington equipment, especially applicable in the petroleum field: WP-1027, Worthington Equipment for the Refinery and Natural Gasoline Plant; WP-111-B6, Worthington HiVol Piston Pumps; WP-101-B3, Worthington Horizontal Duplex Piston Pumps—Type VB; WP-101-B4, Worthington Horizontal Duplex Piston Pumps —Type VD; W-312-B1, Worthington

Centrifugal Pumps for Refineries—Type LT; W-318-B2, Worthington Centrifugal Pumps for Refineries—Type UT, Two-stage; W-318-B3, Worthington Centrifugal Pumps for Refineries—Type UV, Four-stage; and W-318-B1, Worthington Centrifugal Pipe Line Pumps—Types UW, UX, UY.

YARNALL-WARING Co., Philadelphia, Pa., has just issued Catalog WG-1803 under the title "Protection for Boilers." This catalog covers the improved line of Yarway floatless Hi-Lo alarm water column and Yarway vertical and Sesure inclined water level gages for boilers.

AMERICAN STEAM PUMP Co., Battle Creek, Mich., has issued Bulletin 294 dealing with Redi-Oiled piston packed duplex power pumps; Bulletin 401 describing the features of the type MUE single stage, end suction centrifugal motor units; Bulletin No. 75 entitled "Barton Centrifugal Fire Pumps" and another bulletin entitled "Proctor-Keefe Fire Apparatus" all of which contain specific information on the pumps dealt with in the bulletins.

A. P. GREEN FIRE BRICK Co., Mexico, Mo., in a recently published bulletin announces a new controlled insulating firebrick known as G-25. Manufactured under controlled conditions at every stage, G-25 is a highly porous brick with innumerable non-communicating cells with highly desirable physical characteristics. The bulletin gives technical information bearing on G-25.

THE DAYTON RUBBER MFG. Co., Dayton, Ohio, has just issued its catalog No. 160 under the title of Dayton V-Flat Drives, which is devoted to a technical description of the construction and application of a drive which consists of V-belt for use in general industrial service where large speed ratios and very short centers are involved. The drive differs from the V-belt drive in that the large pulley is flat instead of grooved, the bottom surface of the V-belts riding on the flat surface of the large pulley. Speed ratios for this type drive are most favorable when at least three to one or more, and the center distance is approximately equal to or slightly less than the diameter of the large flat pulley. The advantage of the V-flat drive is principally in the lower cost of flat pulley as compared with a similar grooved pulley.

USES FOR the air-acetylene flame are described in an 8-page booklet, covering the outfit used and fields for its usefulness in soldering, brazing or heating operations. The booklet may be obtained from Linde Air Products Co., New York, N. Y.

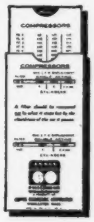
INGERSOLL-RAND Co., New York City, recently issued a bulletin entitled "Jackbits," which shows large cross sectional drawings of the form of thread used on Jackbits and Jackbit rods, and includes tables of rod types and sizes, with dimensional drawings of various shanks.

CENTRIFUGAL PUMPS, Type C, CA and CB, in sizes from 1 to 8 in., for direct connection or belt drive, are described in a 6-page bulletin issued by the Worthington Pump & Machinery Corp., Harrison, N. J.

ALFOL INSULATION Co., Inc., New York City, has issued a bulletin under the title "27 Reasons Why Architects, Builders and Owners Use Alfol House Insulation" which contains some technical information which will be found valuable to engineers confronted with heating problems.

HORIZONTAL DUPLEX steam pumps for general service of sizes from 3 by 2 by 3 in. to 10 by 7 by 10 in., pressures up to 250 lb. per sq. in. are shown in a new 4 pp. bulletin issued by the Worthington Pump & Machinery Corp., Harrison, N. J.

TO TAKE THE place of complicated arithmetic in figuring the correct capacity of air filter, the Coppus Engineering Corporation, Worcester, Mass., is furnishing air compressor and internal combustion engine salesmen with pocket slide-rules which give the desired information in a half a minute. The slide rule is a celluloid pocket containing a sliding chart on one side of which are columns of C.F.M. displacement figures for compressors and on the other side horsepower figures for engines. These figures pass by slots in the pockets which correspond with the number of cylinders. The proper filter size comes into view with the capacity figure. There are two sets of slots on each side, for single acting and double acting compressors and 4 cycle and 2 cycle engines.



FUNDAMENTALS of the art of conditioning boiler feedwater and the latest developments are presented in a new Bulletin No. 689, sent out by Cochrane Corp., Philadelphia, Pa.

Besides describing hot process softeners, cold process softeners and zeolite softeners, this publication discusses chemical principles utilized, the interpretations of water analysis with respect to scale-forming character and corrosiveness, also molecular and equivalent weights of substances appearing in the chemistry of water softening, and chemical reactions involved. The operation of high pressure boilers, including the use of phosphate to remove the last traces of scale-forming matter while retaining a desirable ratio of sulphate to carbonate to prevent embrittlement of boiler plates, receives particular attention.

A NEW CATALOG on Electric Instruments has recently been issued by the General Electric Co. This catalog, known as G.E.A. 602D, is an attractive 162-page illustrated book, printed on enameled stock and containing complete descriptive information on electric instruments of all kinds.

PRICE LIST No. 934 has just been issued by the Chicago Rawhide Mfg. Co., manufacturers of the "Perfect" Oil Seal.

A NEW V-BELT catalog, for both Multiple-groove and fractional horsepower drives, has been issued by the L. H. Gilmer Co., Tacony, Philadelphia, Pa.

WORTHINGTON AIR Compressor Units, Type VA-2 for repair shops and general service, are described in leaflet L-620B7A, just issued by Worthington Pump and Machinery Corp., Harrison, N. J. These are small compact units made in capacities of from 3.9 to 53 cu. ft. of air per min. at pressures of 150 to 200 lb.

RIGHTS OF EMPLOYERS in the Inventions of Employees is the title of a 24-p. booklet issued by Murray & Murray, Monadnock Blk., Chicago, which may be had free on request.

"REDLER CONTINUOUS FLOW Conveyors" is the name of a new catalog just issued by The Redler Conveyor Company, New York, N. Y. The Redler Conveyor involves a new principle in the conveying of material and is adaptable for use with coal, ash, cement, flour, sawdust, etc. By their use bulk materials are actually caused to flow in a solid undisturbed volume through smooth steel casings. This catalog describes its principles and construction and shows numerous applications.

HAYS MFG. Co., Erie, Pa., has issued a new catalog describing and illustration the application of Hays double seal connections and fittings. These seals are used to make connections between copper tubing—a joint that is tight and easily made and easily broken with a pipe wrench. The catalog is well written and contains much useful information for all those who can use copper pipe and tubing.

CATALOG 10-A published by Roller-Smith Co., New York, N. Y., is devoted to a description of their newly developed "Kathetron" Manual Regulator, a thermionic tube device used for the control of voltage below or above normal. This is an extremely flexible method of distant control with small losses at low voltage. It has many applications and is unusually smooth and quick in its response. These regulators can be supplied for almost any rating.

TWO LEAFLETS recently published by Worthington Pump and Machinery Corp. describe their centrifugal and horizontal piston pumps respectively. Bulletin W-312-B3 describes Type L Single Stage Volute Pumps No. 8 and Bulletin W-101-B2 Horizontal Duplex Piston Pumps for general service. Sizes and specifications are given.

ELLIOTT Co., Jeannette, Pa., has published Bulletin G-5 on "Steam Jet Vacuum Cooling Equipment". This 16-page publication illustrates and describes Elliott vacuum refrigeration units, their principle of operation, hook-up, component parts. A diagrammatic view shows the cycle of operation, and two flow diagrams show the application of vacuum cooling equipment to both air conditioning and process cooling.

TO CELEBRATE one-half century of business progress, the Harnischfeger Corp. of Milwaukee has just published an attractive anniversary book entitled The Fiftieth Year. With gold and purple cover and 84 lavishly illustrated pages, this book, by word and picture, tells the story of an organization, its struggles against all manner of adversities, and the pioneering of many types of equipment which play important roles in American industry today. In the early 80's two young mechanical engineers in Milwaukee began manufacturing the first tri-motored electric cranes which led to the manufacture of more than 12,000 cranes and established P&H among the foremost builders of this equipment. The Fiftieth Year tells the story of these achievements. Copies are being presented to friends and patrons of the corporation as a greeting on its golden anniversary. Executives desiring copies will receive them by addressing a request on company stationary to the Harnischfeger Corp., Milwaukee, Wis.

Power Plant Construction News

Ariz., Tombstone—Mellgren Mines Corporation, recently organized, care of Louis Heilbron, Texarkana, Tex., treasurer, plans installation of electric power equipment at local silver and gold mining properties. New milling plant is proposed. Financing is being arranged to total $420,000, considerable portion of fund to be used for purpose noted. R. E. Grace, Phoenix, Ariz., is secretary.

Calif., Bakersfield—Bakersfield Brewing Co., care of C. Fred Baker, 1660 Chester Avenue, Bakersfield, secretary, plans installation of power equipment in new brewery on Sixteenth Street, near M Street. Entire project will cost about $100,000.

Calif., Lodi—Monarch Winery Co., Victor Road, plans installation of electric power equipment in new local winery, consisting of several units with main structure, 100 x 150 ft. Entire project will cost about $45,000. Leo Starr will be in charge of erection.

Fla., Tampa — Peninsular Refining Corporation, Tampa, care of H. E. Nott, Tampa, secretary and treasurer, plans installation of power equipment, pumping machinery, steel tanks and other mechanical equipment in new oil refinery on local site. Financing is being arranged to net about $335,000, considerable portion of fund to be used for purpose noted.

Ill., Riverdale—Acme Steel Co., 2840 South Archer Avenue, Chicago, Ill., plans installation of electric power equipment in new two-story addition to strip mill at Riverdale. Entire project will cost over $200,000.

Ind., Austin—Public Service Co. of Indiana, Traction Building, Indianapolis, plans new power substation, transmission and distributing lines for light and power service at Austin. Cost about $65,000. Company engineering department is in charge.

Ky., Jeffersontown—A. Ph. Stitzel Co., affiliated with W. L. Weller & Sons, Starks Building, Louisville, Ky., distillers, plans installation of electric power equipment in proposed new distilling plant in vicinity of Jeffersontown. Entire project will cost over $50,000. Julian P. Van Winkle is president of first noted company.

Md., Baltimore—Chieftain Mfg. Co., Clinton and O'Donnel Streets, plans installation of electric power equipment in new three-story addition to shoe polish manufacturing plant. Cost close to $50,000. Benjamin Frank, 517 North Charles Street, is architect.

Md., Baltimore—Globe Brewing & Mfg. Co., 327 South Hanover Street, plans installation of power equipment in new four-story addition to brewing plant. Entire project will cost close to $80,000. Herbert Aiken, 4115 Ridgewood Road, is architect.

Mass., Worcester — Crompton & Knowles Loom Works, Grand Street, plan extensions and improvements in power house at textile mill machinery plant. New equipment will be installed. Francis J. Sill, East Main Street, Westboro, Mass., is consulting engineer.

Mich., Detroit—Briggs Mfg. Co., 11631 Mack Avenue, manufacturer of steel automobile bodies, plumbing fixtures, etc., plans installation of electric power equipment in new plant additions. Cost over $500,000, with machinery. Giffels & Vallet, Inc., Marquette Building, is architect.

Mich., Wheeler—McClanahan Refineries, Inc., care of Esbern Hanson, Grayling, Mich., vice-president, recently organized as an affiliation of the McClanahan Oil Co., Mount Pleasant, Mich., plans installation of power equipment, pumping machinery, steel tanks, etc., in new oil refining plant in vicinity of Wheeler. Entire project will cost close to $200,000. Walter L. McClanahan is president.

Minn., St. Cloud—City Council has called a special election Oct. 2, to approve proposition for new municipal electric light and power plant, and electrical distribution system. Estimates of cost totaling $1,249,000 have been made by Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer, which will likely prepare plans for detailed project.

Minn., St. Paul—Seeger Refrigerator Co., 850 Arcade Street, manufacturer of refrigerators, cabinets, etc., plans installation of electric power equipment in two new plant additions. Entire project will cost close to $75,000. C. H. Johnston, 360 Robert Street, city, is architect. Walter G. Seeger is vice-president.

N. Y., Auburn—City Council, William B. Patterson, city manager, plans early call for bids for municipal electric power plant, using Diesel engine-generating units, and new street-lighting system. Cost bout $310,000. Burrs & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

N. Y., New York—Municipal Department of Correction, Municipal Building, plans construction of power house at new city jail on 158th Street, near Gerard Avenue, Bronx. Fund of $989,200 has been secured for entire project through Federal aid.

Ohio, Chillicothe — Mead Corporation, Chillicothe, manufacturer of pulp and paper products, plans installation of electric power equipment in connection with proposed rebuilding of experimental laboratory, recently destroyed by fire. Loss over $65,000. Alan G. Goldsmith is secretary.

Ohio, Dayton—Contracting Officer, Material Division, United States Air Corps, Wright Field, Dayton, will receive bids until Oct. 28 for four air-cooled compressors, V-belt driven (Circular 116).

Ohio, Toledo—Chesapeake & Ohio Railway Co., Richmond, Va., plans addition to ore and coal docks at Presque Isle, near Toledo, with installation of conveying, elevating, loading and other mechanical-handling equipment, with electric power service for operation. Cost close to $500,000. Company engineering department in charge.

Ohio, Youngstown — Youngstown Steel Door Co., Meridian Road, plans installation of electric power equipment in new one-story plant addition. Entire project will cost about $75,000. H. H. Hendricks is manager.

Ont., Toronto—Noranda Power Co., Ltd., subsidiary of Noranda Mines, Ltd., Royal Bank Building, Toronto, plans new hydroelectric power plant on Victoria River, with initial capacity of 20,000-hp. for service at gold-mining properties of parent organization. Cost close to $400,000. Fred A. Gaby, Toronto, formerly chief engineer for Ontario Hydro-Electric Power Commission, is consulting engineer.

Pa., New Castle—City Council is having report and estimates of cost made by Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer, for proposed municipal electric light and power plant, and electrical distribution system.

Pa., Philadelphia—Resinous Products & Chemical Co., 222 West Washington Square, plans installation of electric power equipment in new two-story plant at Richmond and Brill Streets. Cost about $70,000.

S. C., Pinopolis—Santee-Cooper Authority, care of Mayor Burnet Maybank, Charleston, S. C., is considering plans and estimates of cost submitted by Foundation Co., 120 Liberty Street, and Murray & Flood, 369 Lexington Avenue, both New York, N. Y., engineers, for proposed hydroelectric power project on Santee River, vicinity of Pinopolis, with capacity of 200,000-hp. Project will include power substations and switching stations, and transmission lines about 475 miles long for service in coastal district of State. Entire program will cost about $25,000,000. Financing will be arranged through Federal aid.

Tenn., Memphis — Blough, Inc., Memphis, manufacturer of drug and chemical products, plans installation of electric power equipment in connection with new plant additions. Cost about $500,000.

Texas, El Paso—Board of Directors, Fred Douglass National Tubercular Hospital for Negroes, care of Percy W. McGhee, architect, plans construction of steam-electric power plant at proposed institutional buildings on site near city, to be equipped with three 200-hp. Diesel engine-generating units and accessories. Also will install pumping plant, steel tank and tower and other equipment for water supply. Entire project estimated to cost $2,500,000. Financing will be arranged through Federal aid. L. A. Nixon, M.D., El Paso, is president.

Texas, Galveston — Todd-Galveston Drydocks, Inc., a subsidiary of Todd Shipyards Corporation, 25 Broadway, New York, N. Y., plans installation of electric power equipment, hoists and conveyors, and other mechanical equipment in connection with expansion program at former local plant of Galveston Dry Dock & Construction Co., recently acquired. New 10,000-ton drydock will be built. Entire project will cost over $350,000.

W. Va., Grafton—United States Engineer Office, Pittsburgh, Pa., plans construction of hydroelectric generating plant in connection with new reservoir dam on Monongahela River, Tygart Valley district, near Grafton. Dam will be of straight gravity type, with height of 237 ft. above foundation and crest line of about 1850 ft.; bids for dam construction will soon be asked, closing about Oct. 15. Bids for power development will be called at later date. Federal appropriation of $10,000,000 has been made for project.